

# THE FUNCTION OF SCIENCE IN THE MODERN STATE.

PEARSON

UNIVERSITY OF LONDON
GALTON LABORATORY FOR NATIONAL EUGENICS

EUGENICS LECTURE SERIES. XII.

# The Function of Science in the Modern State

BY

KARL PEARSON, F.R.S.

*SECOND EDITION*

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## PREFACE TO SECOND EDITION

This paper was first published in 1902 as a prefatory essay to Volume XXXII of the tenth edition of the *Encyclopaedia Britannica* and is now reprinted from that work. Sixteen years ago it failed to attract any notice, notwithstanding the lesson we ought to have learnt from the catastrophes of the South African War. The next decade will show whether these last four years of struggle—which were in a high degree a struggle for our national survival—have taught us the essential lesson that science is of fundamental importance not only for the survival of the state in war, but still more for its survival in the contests of *peace*. Science has largely organized the nation for war, although at every turn it has had to struggle against ignorance in executive authority. There is an even worse delusion than believing that it is possible to muddle through in war-time, that is the delusion that it is possible to muddle through in peace-time —especially in such a peace as is now before us. If we found it hard to withstand foreign competition, when the best minds among our opponents were turned to the art of war, how shall we meet them again when those minds released from the mirage of the past half century are once more occupied with the arts of peace? Personally I have never accepted the position claimed for German science by its national expositors, still less by its admirers in this country during the twentieth century. But I should

not be surprised to see a real renascence of scientific originality in Germany—comparable with that of 1860 to 1880—if its intellect be freed from the incubus of militarism. How can we meet that coming organization for the contests of peace? Only by freeing our state executive from the dominance of minds trained solely on literature and jurisprudence, and recognizing that in the modern state the function of science—science in its broadest sense, namely the observation of facts, physical, organic and mental, and the analysis of the observed sequences—extends not only to every department of administration but to all those branches of national activity, which it is the duty of the true statesman not only to foster, but if necessary to create.

It is no longer possible either in transport and distribution or in production itself to leave affairs to the initiative of the individual drawn to the field by the desire for profit. He will naturally seek the field of easy tilth and of quick returns regardless of whether he exhausts the soil or not. It is the state alone which can pursue knowledge, which can develop activities, which can store material wealth with a view to distant profit. It alone has continued existence, while the individual stretches out his hands for sufficiency or pleasure in his own brief day. He looks only to those phases of science which are of quick and easy application—and there is very little science to-day which is of that character. The individual looks to his own special corner, and may welcome a specialist to aid him, if such an one is forthcoming, if the trained mind is already there. But it is not his job to produce trained

minds in general, and the fostering of that production must be left to the community, that is to the state. The state in the past has not fostered that production to anything like the necessary extent. When Armageddon was upon us ignorance in authority had no better use for trained minds than to send them to handle cannon with uncomputed range tables, to fire guns without sights, to man-carry rations, where it should have run a light-railway, or to speak over single-wire field telephones because it knew nothing of induction. When the history of the present war is really written one of the most curious chapters will be the marvellous manner in which in almost every field the scientific layman has come to the aid of executive ignorance.

Are we to return to the old order of things now the war is over, or shall science continue to exercise its proper function in the state in the harder contests of the coming peace? I venture to think some of the reforms advocated in this paper of 1902 would have helped us had they been carried out before 1914, and I believe that some of those still outstanding if now adopted could not fail to help us in the coming contests of peace.

K. P.

*February* 1, 1919.

# THE FUNCTION OF SCIENCE IN THE MODERN STATE[1]

## I

## SCIENCE AND THE STRUCTURE OF THE MODERN STATE

*Biological theory of the state*

BEFORE the second half of the nineteenth century a true theory of the state was impossible. A sound idea of mankind as but one among many types of life, even if the highest type, had hardly entered men's minds—they were accustomed to contrast "nature" and "man." But had it entered, they knew so little about the laws governing any form of life, that they would not have gained much by extending the little known to man. Not till the publication of Darwin's epoch-making works was a real appreciation of man's position in the evolution of living forms possible, and with this appreciation all the old theories of the state became practically idle—landmarks only in the study, ever-interesting to man, of the history of human thoughts and theories. A complete revolution was wrought in the ideas of those who read and understood Darwin, both as to the nature of the state and as to its functions. The theory of the state could no longer be treated from either the philosophical or the

[1] It must be understood that this is the briefest sketch of a vast and all-important subject, where the writer has not been able at every turn to develop detailed plans, but only to outline suggestion and criticism.

purely logistic standpoint. The state was the product of an historical evolution; the nation was a unity evolved by the struggle of one living type under the same laws as applied to other phases of life. The theory of the state became biological: one of the most complex and difficult branches of biology no doubt; but still it was a great step to remove this theory from philosophy—or even from metaphysics, as in the case of Hegel—and transfer it to its true class.

It is little wonder, perhaps, that the first investigators in this new field went widely astray. They extended without due thought fascinating biological hypotheses to the case of man. They found the struggle of individual against individual in many vital fields, and they extended the survival of the fitter as a governing principle to all individual life within human communities; they did not stay to inquire why and how communities had themselves come into existence; they neglected the suggestions of the hive and the herd, and reached (as in the cases of both Spencer and Huxley) fallacious conclusions as to the functions of the state and the sources of social conduct. In short, they over-emphasized the intra-racial struggle, and under-emphasized the inter-racial contest, as factors producing and developing the political and moral characteristics in man. Other state theorists, again, accepted without qualification some doctrine like that of panmixia, unproven or even disproven for the lower types of life, and heedlessly applied it to civilized man. Nor were these over-hasty conclusions to be entirely con-

demned: by the discovery of the doctrine of evolution by natural selection, an absolutely new country had been thrown open, with endless possibilities for thought and action. What wonder if publicists, with no sound biological training, indeed no scientific training whatever, rushed in with jubilation to be among the early settlers? What wonder that biologists, with small historical knowledge, even without intimate acquaintance with the exact social history of any human community for the briefest of periods, extended at once great vital principles beyond their legitimate limits?

We can scarcely be surprised that some false views as to man and the state were propounded under the new impetus, or that some mistakes were made even in social legislation. Reaction was certain to come, and the cycle was completed, as usual, by a German professor demonstrating all Darwinian theory to be snare and delusion.

Let us then at the present moment take stock and see where we actually stand. The main principle of evolution by natural selection is based upon four factors:—(*a*) That characters are variable. (*b*) That characters are inherited. (*c*) That there is a selective death-rate, *i.e.*, that individuals possessing characters or combinations of characters in a higher or less degree than other individuals die, on the whole, sooner or later than the latter. (*d*) That those individuals who die early leave fewer offspring than those who die late. How far are these factors demonstrable truths in the case of civilized man?

*Darwinian theory and man*

(*a*) This is beyond question for both physique and intelligence in man.

(*b*) This is absolutely certain for both the mental and physical characters in man. Both these are sensibly inherited at the same rate and, further, with such a degree of intensity that three, or at most four, generations of selection will suffice to establish a race in man which will breed true to itself under a stable environment.

(*c*) By observations on the death-rate of relatives —*i.e.*, of groups of individuals possessing like characters or combinations of characters—it has been demonstrated that 50 to 80 per cent. of the deaths among mankind are selective.

(*d*) This has been statistically demonstrated for both sexes in Great Britain, America, and Australia.

We are forced, then, to the conclusion that the Darwinian theory in the case of mankind is a law and not a "plausible hypothesis." It is a different problem to measure the rate at which evolution works. What sensible modifications can be made within 200, or even 8000, years in a human race by evolution? Recent craniological investigations seem to show that, even within the shorter of these periods, such changes can occur in the shape of the skull of a single race that 50,000 years or less would suffice to have modified the cranium from a type which any modern anatomist would hesitate to call human. The argument is not that the human skull has always gone forward at this rate, but that it could do so under apparently quite ordinary conditions. In other words, the biologist's demand for time must not be looked

upon as indefinitely exceeding what the geologist is prepared to grant.

Such is our modern stock-taking—a possibility of the work done between 1890 and 1902—of the relation of the Darwinian theory to man.

*The international struggle for existence*

But if we only apply the principle that all life progresses by the struggle of individual against individual to the history of man, we find half the facts of both social and political history wholly unintelligible. We have missed the great point, that man has largely progressed because he is gregarious; we cannot describe on such a basis the evolution of morality, the origins of tribal customs, tribal worship, national institutions, national religions, and, ultimately, of the modern state. We might as well attempt, on the basis of the survival of the fitter individual, a satisfactory explanation of why Sir Harry Johnston's African ant gave forth, when trodden on, a most appalling stench, so skunk-like that the destroyer fled from the spot. The welfare of the whole has controlled in this case, as in others, the development of the individual. The community in its entirety is struggling against its vital and physical environments. As soon as we interpret the facts of history in the light of progress by inter-racial struggle, and only in a secondary manner by intra-racial competition, those facts become deeply suggestive and significant for our guidance. We see both Roman and Hebrew nations arising from very small beginnings by successful variations in tribal custom and belief. We no longer mourn over the apparent waste

of power in the continuous wars of the small Greek communities: we see in that strife the probable source of their rapid progress in intelligence and physique. Nay, modern Europe itself at once becomes the stage whereon the drama of evolution is being played out amid the hum of factories, the clash of armaments, and the buzz of youth in the playing-field and the lecture-room. History has painted for us the ever-present strife of nations: in the lower stages we see the victory of brute force and of cunning; in somewhat higher stages we find the dominance of strength, valour, and discipline; at the present the factors of mastery are possession of material sources and the skill to turn them to account, —the copious store of knowledge, the power to increase it at will, and the intelligence to apply it for the national profit. The struggle of nations is the commonplace of history; but the realization that this struggle is a factor in human development,—that big battalions or an armada are not sufficient insurance for success in it, but that organization and intelligence in every function of national life are requisite for victory,—this is the special truth that dawned upon us at the end of the nineteenth century. Formerly territory was blindly seized, trade routes and commercial markets blindly opened or controlled, manufacturing processes and means of transit developed or not, according as they might seem profitable or not to individuals. The bearing of these things and a multitude of others—such as the physique of the nation, the skill of its craftsmen, the intelligence of its trade-leaders, the activity of its educators, the

organization and preservation of its material resources—was unrecognized in their relation to national fitness for the international struggle. The politician could tell the nation that it must have more ships or more rifles for the national safety, or he could emphasize the importance of the "open door" for national welfare, but he did not provide for the intelligent building of the ships, the intelligent sighting of the rifles, the intelligent training of the merchants who were to enter the open door amid the great international crush to get inside. He did not see that ultimately the training of even the apparently most insignificant workers in the community, the fitness for its purpose of the simplest manufacturing or agricultural process, may be vital to a nation in the evenly balanced contest of modern civilization. To stand still—for a moment to depend only on the possession of material resources, of the existing trade routes, or of means of transit—is to lose points in the game. Where all are pressing forward, not to advance is to fall behind.

*Factors of national success*

Let us consider for a moment some of the factors of national welfare. First, the physical powers of the nation—*vital*: its numbers and effective fertility, its health and sanitation, the energy, vigour, and absolute strength of individuals; *material*: mineral wealth, sources of mechanical energy, coal, oil, water power, water and rail transit, docks, coaling stations; *equipment*: power to seize and power to hold. Secondly, the mental powers of a nation—power to carry out mechanical work quickly and effectively; power to

discover and power to imagine, to incite and to stimulate:—*morale* and patriotism; power to resist long strain, to avoid epochs of national hysteria, to follow for years definite policies with only future profit in view, to govern effectively, or ultimately assimilate divergent racial groups. On examination, each one of these and other factors of national efficiency will be found to require intelligent handling: they demand training and knowledge—science in its broadest sense—if the stability of the state is to be maintained and increased, if the nation is to contribute its full share to the total progress of human activity.

*Trained intelligence at the basis of national fitness*

The future is to the nations which not only realize the international struggle in all fields of activity, but consciously develop all the factors of national efficiency with this end in view. This is the theory of national life which presents itself at the beginning of the twentieth century. It connotes an immense development of the functions of science in both legislature and executive. It should lead to new conceptions of, and new scope for, patriotism, and a revised attitude towards state action and state service. Brute force, strength and bravery, material wealth, have in turn been dominant in the state; to-morrow will be marked by the dominance of intelligence. The most intelligent nations will be victorious in the struggle; and it befits each state that would be great to-morrow as well as to-day to educate and organize itself, from the statesmen at the top to the ploughboys and factory hands at the basis. In the future it

will not be possible either to organize and lead a nation or to make a cheese effectively without training —without a knowledge of what science has to say about men or milk.

*Significance of class and caste*

The education of the nation, from statesman to dairymaid, is a task of great magnitude—more especially in old countries, where the institutions have developed historically, and often preserved features of earlier periods, when other factors than intelligence were dominant in national life. On the other hand, the older nations possess traditions and divisions which are not without service as rough results of experience. Caste and class may be exaggerated so much that they do far more harm than good, but to a certain extent they may serve for differentiating workers within the community. The nation stands equally in need of its ploughmen, its craftsmen, its traders, its brain-workers, and its leaders; and it is desirable to have some preliminary classification of what work an individual is best suited for. While, on the one hand, it is most important that all capacity which will be of special social service in performing a particular function shall find that function within its reach, it is, on the other hand, not only undesirable, but impossible, to subject every individual in the nation to a test of fitness for every possible calling. With rough practical efficiency a man's work in life is settled by his caste or class. This is not so undesirable as it might at first sight appear; it is a largely unconscious differentiation of the nation into workers of different

types, who marry within their caste, and—if we remember how few generations are needful for a special human group to breed true—thus preserve to a large extent their special usefulness. We need a net which will be widely cast to drag upwards, and a similar net to drag *downwards*, but the meshes of neither of these nets should be too small. It is cruel to the individual, it serves no social purpose, to drag a man of only moderate intellectual power from the hand-working to the brain-working group; yet this seems too often the result of the present system. If there be a moderately capable worker, the state should strive, in the first place, that he should be trained to better craftsmanship. Do not let it assume that he will turn out a Faraday because he shows some relative capacity. In at least nine cases out of ten disappointment will be in store for the state if it does. Let there be a ladder from class to class, and occupation to occupation, but let it not be a very easy ladder to climb; great ability will get up, and that is all that is socially advantageous. We have to remember, for example, that the middle class in England, which stands there for intellectual culture and brain-work, is the product of generations of selection from other classes and of in-marriage. A hundred men of this class, quite apart from training and tradition, will provide a greater percentage of men capable of doing brain-work, than a hundred men from the farming class, or a hundred craftsmen[1]. These in their turn

[1] The cry for "an easy ladder" is a most mistaken one, especially as long as any false feeling of gentility attaches to one or another class of workers. During the last few years the

(if we do not regard training and tradition, though there is no reason why we should not) will produce a larger proportion of men suited for colonists or for the workshop than the former, and for precisely the same reasons—long selection and in-marriage. Again, we assert, the gradation of the body social is not a mere historical anomaly; it is largely the result of long-continued selection, economically differentiating the community into classes roughly fitted to certain types of work. And here we reach the first fundamental principle in the education of a community: the education must be specialized for each individual class of workers—all intelligence must not be driven through the same mill. The system under which local colleges ape universities, polytechnics ape local colleges, night-schools ape polytechnics, and all think it the highest merit to get their students stamped with a degree of one kind or another, is an

writer has come largely in contact with a number of young men and women whom the county councils up and down the country are educating at the national expense. These county council scholars are on the average not up to the mean middle-class intelligence. It is very rarely that one could not pick out for any given post better, often many better, middle-class candidates. In this case the meshes of the net are far too small: ten per cent. of the scholarships would have sufficed to procure the really capable men and women whom it was of social value to educate for intellectual pursuits. The rest want either the originality, the power of self-assertion, or the physique which would enable them to force their way forward in a new sphere. The bitterness of failure is upon those, who, scholarships ended, sink to usherdom in small private schools, or to second-rate draughtsmen in engineering works. Taught in true craft-schools, they might well have been leaders in their own class, instead of failures in another.

utterly fallacious one; it is educational chaos, and has not the slightest approach to that harmonious system of education differentiated to class-function and class-intelligence, which must be at the basis of national fitness, *i.e.*, the readiness of each group in the community to do its specialized work efficiently. Let there be a ladder then, that indisputable capacity may climb to the place where it is most wanted, but the nation needs that the great bulk of its members shall work at the same tasks as their forefathers, only with increased intelligence and more highly developed craftsmanship. Make it easy for the Michael Faradays to climb, but only for such as he was; the increase of the intellectual proletariat is a sign not of efficiency but of chaos in national education.

*Need of specialization in education*

If national education at the present day be a *sine quâ non* of national fitness for success in the world-struggle, it must none the less be a specialized education suited to develop the intelligence of each caste and class. Training is essential to a nation, but it must be specialized to each social activity, if it is to perform its function. How is this truth to be brought home to the statesmen, the permanent officials, or the politicians, who alone can bring order into educational chaos? The statesmen of the old school, blamelessly ignorant of the laws of national development, were inclined to look upon race-progress as due to mighty forces beyond human control, and thus to believe that executive and legislature could do little to make or mar national welfare. But as we learn to understand better the laws ruling

living organisms, our appreciation of the factors in human history changes: man cannot modify the law of gravitation, but he can make its effects subserve his own ends; and this is equally true of the laws which rule organic and inorganic material.

*Training of the statesman*

Unfortunately the training of the statesman himself is often sadly defective; he rarely stands at the summit of the knowledge of his day, or has the instinct to select his subordinates for real organizing power. In a democratic state the process by which the statesman is chosen is at best a risky one. His requirements are, first, ample private resources; secondly, power to impress a possibly well-meaning but largely ignorant democratic electorate; and lastly, ready debating power and personal influence on the somewhat narrow group, chiefly of his own type, which is to be found in the average representative assembly. There is no security in these requisites for a training in statecraft. The race-leaders and potential empire-builders rarely find their way into representative assemblies. The men who could organize a great national department, or even organize the nation itself, devote their energies to the building up of world-wide commercial enterprises to their own profit, or to the profit of a narrow circle. And when such men have convinced the world of their business capacity, of the shrewdness with which they can appreciate new ideas and forestall the future, they are already beyond their prime. They have no longer the inclination to learn the complex routine of parliamentary life, or the power to stand its physical strain.

One of the most difficult problems for the democratic state is to make state-service in its highest branches a career for such men in their youth, and thus allow the nation to exploit at once and directly their power of initiation and organization. Still more difficult, perhaps, is the selection of statesmen in the case of an oligarchy. The nation which bred and trained a specialized class of men solely for statesmanship would undoubtedly be best governed under such a true aristocracy. But in practice the existing false aristocracies fall far short of serving any such state function. There is no security that the dominant caste represents either the intelligence or the organizing power of the community. Even if the caste be based on wealth-accumulating power or state-service of ancestry, there is no security for the brain-power indicated in past success being preserved by inheritance, unless the maintenance of family ability becomes a far more conscious guide in the arrangement of matrimonial alliances than it appears to be in any aristocracy of the present day. Further, little, if any, specialized training has hitherto been provided for such a class beyond the educative experience of men and manners—which may legitimately be considered a trifle narrow—to be gained in a parliamentary career and the earlier stages of executive life. Without proper selection or fit training the statesmen of the oligarchy may forget inter-racial competition under the bias of class interest, and the intra-racial dominance of a caste become the chief object of a false statecraft.

A secure autocracy hardly affords a like foothold

for intra-racial struggle weakening the effective response of a nation to its environment. But its success depends so entirely on a single throw of the dice—the discovery of a man with unique powers of selecting intelligence and organizing ability in his immediate subordinates—that it need hardly be considered as a practical form of government. The discovery of the ideal dictator is a problem which finds not even an approximate solution in elected presidents, still less in hereditary autocrats. It is true that revolutionary processes by which the really strong man comes to the top may occasionally aid a nation at a time of crisis, but they are too expensive in other ways to be aught but a counsel of despair. Historical evolution has left most civilized nations, after a rough and tumble experience, with a democratic government more or less tempered by oligarchic and autocratic institutions. This may be the best practical solution of the problem in the present stage of national development, but such a system is terribly cumbersome in its processes for ensuring that the keenest brains and the best organizing power of individuals shall be secured as the brains and the organizing power of the nation at large. If the best trained, the most intelligent community is destined to be the surviving type of the present century, then the cry must not only be: Educate your democracy! but also: Select and train your aristocracy for statecraft!

If we may assume, and there is small doubt that we safely may assume, that all qualities in man are inherited, and inherited at such a rate that very few

—two to four—generations suffice for selection to produce a class breeding true to itself, then the selection of an aristocracy even by the rough process of ennobling great ability or great wealth (acquired by the owner) is intelligible. But the continuous support by the nation of members of an oligarchic class who have ceased to be of service for aristocratic purposes is futile. In the fourth generation at latest such members should drop out, unless the stock has again proved its capacity by effective national service. The absence of such service will be a sure sign that the original ability was sporadic, that the stock has not bred true, has wasted its intellectual patrimony, or has neglected to train itself for its special functions. The net—meshes not too small, let us remember—must drag *downwards* as well as upwards.

*Need for a school of statecraft*

The training of an oligarchic class in statecraft is the first and perhaps hardest task of the modern state. Much, very much no doubt, can be learnt from municipal, parliamentary, and minor executive experience by the man who from youth upwards has resources and leisure. But such a training alone is very narrow; it may be supplemented by leisurely travel, and the somewhat superficial knowledge thus gained of the men of other races, their institutions, aims, and modes of thought. As a preliminary, however, to both travel and political experience, a specialized academic training is really needed. There is a demand for a school of statecraft. The idea is not so absurd as it may at first sight appear; nor, on the

other hand, are the chances of its success so great that every university, local college, and night-school should rush to establish a lectureship in statecraft! Special schools are best localized at one or at most two centres; they should grow up naturally by the development in a definite direction of an existing educational centre, which to some extent already attracts the class of men to be catered for. We want a specialization and a modernization, in the light of current biological science, of some existing History School. There should be one school at least, where the political institutions of Germany and France are as well known as those of Greece and Rome; where the chief phases of Indian religious development are as closely appreciated as the theological currents of sixteenth-century Europe; where the nineteenth-century "discovery of Africa" would be discussed and interpreted in its relation to modern European politics, like Columbus's discovery of America has been dealt with as marking the end of the Middle Ages and the collapse of the mediæval system. There should be one school at least where colonial institutions, ambitions, and developments are studied and appreciated; where national customs, racial prejudices, the foreign press, its powers and limitations, are calmly, and apart from political intrigue, investigated and weighed in the balance; where the students' own nation, its comparative power and influence, its *morale*, and its policy are all dealt with in an atmosphere comparatively free from party strife, and at an age when the mental judgment has not had its roadway worn into ruts by the continual

traffic of men and affairs. Sketchy as such a scheme must seem,—its realization could only be a growth,—yet the absence of such a school of statecraft is a partial, if not complete, excuse for ignorance on the part of the leisured and ruling class of more than one modern nation. A class of great ability and organizing power has not only to be gathered together by the drag-net cast over the other classes of the community, but once formed it must have a high tradition in its choice of mates, and a really effective training provided for its members.

The form of government, the right selection of statesmen, is far more important in its bearing upon the true function of science in the state than might at first sight appear. Unless we have the statesman of insight, who recognizes that every function of the state, every phase of national life, has a theory of its own; that there is a right and a wrong way of conducting all state business, whether it be concerned with the wealth, the physique, the intellectual efficiency, or the *morale* of a nation;—we cannot place knowledge—science in its broadest and truest sense—in its rightful position of consultant alongside the executive. We must have stored knowledge, science theoretical or empirical, at the service of the state for the ordinary routine of every department of national activity; we must also have thinkers and discoverers ready to meet new needs and sudden emergencies; there must be in reserve trained brains and deft organizers both of material resources and of living workers, not only for the constant drain of

*Statesmanship and science*

progressive national development, but, above all, to give the community confidence and reasoned guidance in times of national crisis. The universal rivalry of nations at all points of the globe, the rapidity and ease of modern communications, do not give any nation time to wait for the right man for a particular task to turn up. He must be there fully trained and equipped, so that the executive, the commerce, or the commonality of the nation can seize and exploit him at once. If he is not immediately forthcoming, the fruit will drop into the mouth of the nation that had the luck or the foresight to have its man ready for the occasion. Readiness for pioneer-work is one of the best tests for efficiency in the modern state. The mineral wealth, the climate, the agricultural resources of a new territory are to be reported upon with a view to its incorporation or development: the men to do this effectively must be ready trained and at hand. A troublesome native tribe is to be tutored by the touch of the masterhand: the man who can guide them with experience, with knowledge of their language, of their religion and their customs, cannot be reared—he must be forthcoming on the spot. The trade-rivals of a nation discover a chemical procees which threatens some national industry of a second: the chemical or agricultural experts of the latter must be immediately prepared with a process for cheaper manufacture or more intensive production. Another nation invents a smokeless powder or a submarine boat: no neighbouring state can afford to start *de novo* with years of experimental inquiry; its experts—if they have failed, as it is not creditable to have failed,

to be first in the field—must be ready with an immediate and effective reply. No nation can nowadays risk being a single step behindhand in its offensive or defensive services, in its methods of production, of trade or of transit, or in the general education of its citizens,—their craftsmanship and their ingenuity,—or, again, in their average physique and reproductive power.

*Survival of the most intelligent nation*

In the days of old the battle of life was won by the nation with physique, and intelligence enough to guide that physique. To-day victory is to the nation with intelligence, and physique enough to keep that intelligence in healthy activity. In past times the chief store of national power was manual labour: to-day it is the machine that does the work, and not the man; the important things are the brain which organizes and the intelligence which creates and guides the machine. Mineralogical, chemical, engineering knowledge achieve to-day what muscle and brain did a thousand years ago; the chief function of physique is now to maintain the brain in order, and not to act as a machine at the bidding of brain. The old order has changed; from statesman at the helm to craftsman in the shop, modern conditions demand special training, not haphazard selection. Here is the wide function of science in the state. How under existing conditions can science serve the state? How provide guidance in executive, reserves of knowledge, of discovering power, and quick response for emergencies; how train the craftsman, the agriculturalist, the engineer,

to be one and all efficient for the international contest? To touch upon these things will be the object of the second section of this paper.

## II

## SCIENCE AS EDUCATOR

*Primary education*

The subject of primary education is not one on which much can be profitably said here. Its thorny character arises partly from theological difficulties, and partly from the widespread delusion in the minds of those who have received a primary, or even a more advanced education, that this fact alone constitutes them educational experts. Neither aspect of the case is satisfactory from the crucial standpoint of national efficiency: both involve immense waste in time, energy, and *personnel*. Sooner or later the primary schools must fall absolutely into the hands of the state, and, free from direct local control, be managed by a single council of education and a minister responsible to the national assembly. Every other system is merely tinkering at best; there are not sufficient real educational experts in the country to provide the capacity which is needful on innumerable school boards, to say nothing of parish committees and district councils. Local vigilance committees may well be organized to see that the national system is effectively carried out locally, but local bodies are not in the intellectual position to draft an efficient system; nor, if they could do so, are they able either

to put it into practice economically, or to avoid the friction of local sectarian feeling. If intelligence be the keynote to national fitness for the international struggle, the organization of even the primary stages of the nation's training is as much a national affair as the equipment of the nation's forces for offence and defence: it cannot be left to local management, but must be removed to a higher plane of both criticism and executive organization.

*Physical record of nation's children*

But state control of primary schools is not only essential from this aspect, but also from the importance which must be attached to the nation having a complete and uniform record of the physical condition of its children. Is the stamina of the nation being not only maintained but strengthened? This is a question to which the statesman ought to be able to give at once a satisfactory answer. He ought to be in a position to tell us whether fifteen to twenty years hence we shall be as strong and active a nation as we have been in the past. We are too apt to forget the changes that have taken place not only in the nature of the food supplies, but in the very atmosphere our citizens are breathing. What are the effects of urban or suburban dwellings on increasing numbers of the population; of a frozen meat supply kept for months and possibly years; of foreign ground flour; and of innumerable articles of food and medicine prepared in factories, here or abroad, by processes not wholly scientific, and now sold over the whole country? Possibly but little knowledge of the direct effects of such new factors could be obtained

by straightforward inquiry, but a systematic anthropometric record of the schools would tell us whether our children progress or not from generation to generation, and what is the nature of the special precautions, if any, to be taken with regard not only to individuals but to whole localities. Very little extension of the system of observation and measurement would teach the state the effect of particular trades on parentage; the district where special diseases have to be combated; the localities where special physical or mental aptitudes are to be found; and where it is most desirable to establish secondary and craft schools of a specialized character. In Great Britain we have not only many local races, but many mixtures in diverse proportions of these races. How far are such groups particularly suited to specialized activities? It does not follow that because certain industries have sprung up in the neighbourhood of material resources or of means of transit, that the local population is best fitted to carry on these industries; the sorting and sifting of population, the creation of a local sub-race, suitable to a developing local industry, is by no means so rapid as it ought to be[1]. An effective record, made on a common system, of the physique and intelligence of the children of the nation would immensely assist the quest for suitable types of manual labour or of special intelligence.

Or, again, at a time of national stress it may be

[1] The man who wants horses for a particular type of work, to go at a definite speed, or with a definite load, or on a particular type of metal, will generally be able to find a part of the country where horses suitable for his purpose are bred.

important to answer a definite question, which could be at once answered from primary-school records. We may be struck by some defect in our training, we may attribute want of intelligence in our officers or soldiers to the over-emphasis given in our school system to athletic sports. We may be stirred by ringing phrases like "the flannelled fool at the wicket" and "the muddied oaf at the goal," not to change the bat for the rifle, nor the pad for the pigskin, but to condemn sports in the school as lessening the training required for intellectual development. We may attempt to remedy wrongly an admitted national failure through ignorance as to its true source. Here, again, the schools can aid with a proper record. What are the characteristics with which we find the athletic tendency associated in the schoolboy? Science is now ready with an answer[1], which would be far more definite and complete if we could draw our statistics from the wide material of a national record. Association between qualities is measured scientifically by the so-called *coefficient of correlation*, which is really a measure of the average relationship between two qualities—it can take every value between zero and unity. When it is zero, we say the qualities have no relation to each other; when it is unity, we con-

*Relation of athletics to intelligence*

[1] The results given below are based upon measurements and observations of between 5000 to 6000 school children which have been taken for the writer during the last five or six years by the help of school teachers. The inquiry has been aided by a grant from the Royal Society Government Grant Committee.

sider the relationship perfect or causal[1]. When it is positive, the two qualities increase together; when it is negative, the one quality increases as the other decreases, and *vice versâ*. Premising so much, let us inquire in what degree our school record shows the athletic character to be increasingly related to admittedly desirable characteristics. We find, if we define the athletic group to consist of boys not only keen on games but proficient at them, that the relationship between the characters is expressed as follows:—

| | |
|---|---|
| Athletics and good health . . | ·46 |
| Athletics and intelligence . . | ·21 |
| Athletics and quick temper . . | ·22 |
| Athletics and noise . . . | ·35 |
| Athletics and popularity . . | ·33 |
| Athletics and self-consciousness . | ·08 |

[1] The following series indicates the closeness of correlation in various qualities for purposes of comparison:

*High Correlation*, 1 to ·75.

| | |
|---|---|
| Right and left femurs in man . . . . . | ·96 |
| Bone length, right and left little fingers in man . | ·90 |
| Stature and femur in man . . . . . | ·80 |
| Left middle finger and foot in man . . . . | ·76 |

*Considerable Correlation*, ·75 to ·5.

| | |
|---|---|
| Stature and foot length in man . . . . | ·74 |
| Weight and length of new-born infants . . . | ·63 |
| Vaccination and recovery in cases of smallpox . . | ·60 |
| Statures of father and son . . . . . | ·51 |

*Moderate Correlation*, ·5 to ·25.

| | |
|---|---|
| Out-relief rates and pauperism . . . . | ·48 |
| Degree of foveation and severity of smallpox attack in vaccinated persons . . . . . | ·40 |
| Coat colours of horse and grandsire . . . . | ·30 |
| Winter barometric heights in Lisbon and Valentia . | ·25 |

*Low Correlation*, ·25 to ·00.

| | |
|---|---|
| Strength of pull and stature in women . . . | ·22 |
| Lengths of lives of mother and adult daughter . | ·15 |
| Sizes of family for mother and daughter . . . | ·11 |
| Size of head and ability in man . . . . | ·06 |

Thus we see that the athletic lad has associated with this character in a very sensible degree: good health, quick temper, and intelligence. His ability in games makes him slightly self-conscious, comparatively noisy, and, as we might expect, popular. He is also rarely *sullen*. Nor is this character substantially the result of his having good health; for we find that the healthy, as distinct from the athletic, have less than half (·09) the association with intelligence, and a scarcely sensible correlation (·03) instead of a fairly high correlation with quick temper. Nor is it a matter of race; for soundness of health is very slightly related to *dark* eye (·07) and *dark* hair (·01) colours, but the *fair* are just sensibly the more athletic (·04). The athletic schoolboy who rejoices in cricket and football is distinctly neither "fool" nor "oaf," but the healthy, intelligent, rather quick-tempered lad who should make a good soldier. Clearly games and aptitude for games ought to be encouraged in the primary school. When and for what they should be laid aside as we approach the real work of life, with its national and industrial demands on the citizen, cannot be profitably studied until we have ample data of the above kind for youth both in the factory and at the university.

*Aims of primary education*

To the observer of childhood playing and questioning are its natural functions, and the teacher in the primary school has to develop nascent intelligence on these lines. Playing skilfully means intelligent use of eye and hand,—it is the basis of efficient craftsmanship in the future. Questioning profitably as to

the meaning of what is seen, is the basis of discovery by observation—it provides the *principia* of scientific training. To turn the ceaseless movements of the healthy child into the co-operative work of eye, hand, and leg, and its too often meaningless "why" into reasoned inquiry, is the first and most difficult task of the primary-school teacher. Organized games developing into the elements of craftsmanship, inquiry into things observed expanding as time goes on into a conception of the methods of science: these must be the essential features of the state primary schools of the future. Facts are to be secondary, methods of the first importance; the intelligent man knows where and how to find his facts, but he retains no more in his head than he finds economical for everyday practice[1]. His brain is an instrument for work, not a lumber-room. Hence when once the barest essentials of elementary knowledge—the power to read, to write, and to do simple calculations—have been attained[2], let us adopt largely heuristic methods—collect facts only as aids to intelligent observation and inquiry, and use biology or mechanics, or history or

[1] Not to know the capital of Servia, the tributaries of the Don, or the constituents of the atmosphere, is no sign of defective education. "Facts" change from generation to generation; but skill in manipulating facts is the fundamental sign of a trained intelligence, of a true education, which survives all modifications of its material.

[2] From the standpoint of economy a certain amount of rote teaching must be admitted in the case of the three R's. It is loss of time to apply the heuristic method to English spelling, or to *every* stage in the multiplication table. Nature-study—physical or biological—offers far more profitable material than adding nines to nines up to 108!

physiography, according to the aptitude of the teacher and the environment of the school, as a means of training intelligence, and not as a store of facts worth remembering for their own sakes. Let the child come out of the primary school able to formulate its questions intelligibly; able to put eye, hand, and leg into co-operative action; able to read, write, and count;—and the first stage in the training of its intelligence to national ends has been attained.

But let it realize in the simplest way that this development of intelligence is not for selfish ends. Bring before it from the earliest day the habits of the herd and the hive as illustrations of united work to a common end; let it see that man is lord of all life because he is the most intelligent *gregarious* animal; teach the child by practice and example the effect of combination, the struggle of the social group against its environment, and the progress man has made in effective resistance by co-operation. Let the child very gradually become conscious of the fact that man is fittest not as individual, but as society. In the broadest outline let it see evolution at work on man, and why the social is "right" and the anti-social "wrong." Let it realize that the strong nation is the intelligent nation; and let it early grasp school-teaching as the first stage to good citizenship, and that only the intelligent man can successfully perform the duties which society and the nation demand from each of their members. Here is a broad enough basis for primary schools in teaching the fundamentals of morality, which each sect may supplement

*Social action as a product of evolution*

in its own special manner. The state, as unsectarian, has first to inculcate the social duties: to emphasize the need of developing the physique, the intelligence, and the spirit of co-operative action as essentials of true patriotism.

*Secondary education*

From primary we may pass to secondary education, wherein we shall find that far greater changes will be needed in the future than seem at all to be anticipated to-day. For while the subject matter of primary education may well be the same for all classes in the nation, modern requirements urgently demand specialization in secondary education, and to a large extent a differentiation of groups, according to the nature of the work they are to undertake in life. This does not necessarily mean a differentiation of method, nor perhaps of location, but certainly of the subject and of the apparatus used to illustrate method. The great bulk of the population are already at fourteen employed in work or in seeking employment. For this portion, at any rate, there ought to be the elements of a secondary education specialized to their calling in life. Besides the state primary schools, there ought to be craft-schools, possibly separate for the two sexes, thickly strewn over the country. These schools, while largely under state control, ought to be subject to a much greater local influence than the primary schools, partly because theological problems will have been for the most part settled at an earlier stage, partly because the needs of local industries are often best appreciated in their immediate neighbourhood.

*Secondary craft-schools*

In these craft-schools we do not want university graduates lecturing upon mechanics or chemistry as they have learnt those subjects in academic text-books or laboratories. We do not want the higher theory of agriculture or engineering such as may be given to the directors and leaders of labour in technical colleges. What is needed is an extension of the object-lesson method of the primary school to the basal forms of labour on which the social fabric ultimately rests. We want to give a system of secondary education to the great bulk of workers, which will make the individual worker an intelligent instrument for his allotted task; we do not require, in the first place, a system which leaves the majority untouched, but raises an artisan here and there to a higher caste. We need a system of education for the bulk of men, who follow, entirely independent of the system requisite for the minority, who organize and lead.

*Rural craft-schools*

The craft-school, in the few years in which it can handle its material, must achieve two things, both tending to strengthen the national fitness for survival, namely, it must lay the basis (1) of good craftsmanship and (2) of good citizenship. Under the first heading no form of labour is to be considered beneath educational treatment. Taking first the rural craft-schools, no agricultural or horticultural process is or ought to be without a basis of scientific theory; hedging and ditching, ploughing, hay-making, harvesting, care and handling of horses, cattle, sheep, and pigs, all that falls to the lot of farm-labourer, shepherd, hind, and groom, can be treated intelligently. They can

all be dealt with by the object-lesson method,—observation, and deduction from what is observed. On the girls' side, milk, butter, cheese, poultry, household work of every description, can be used in the same way as material for showing how to do things intelligently. Education is in no case to leave the feeling that it is finer to follow one trade than another, but is to develop the consciousness that it is a disgrace to follow any craft without intelligent appreciation of the why of its processes. The victory is to the intelligent nation; that nation is intelligent in which each member performs his allotted task with appreciation of how and why it is done.

The pure scientist still occasionally speaks with contempt of the technical side of education. If technical education be merely a knowledge of the facts and formulæ used in special industries, he is entirely in the right; if, on the other hand, technical education means the illustration of scientific method on the material and appliances used in a particular trade or craft, he is hopelessly wrong. It is as possible to give scientific instruction on the apparatus of a craft as upon the delicate toys of the academic physical laboratory. The horse and the pig, the growing crop and the vegetable garden, are as replete with lessons in scientific method as zoological or botanical laboratories with their microtomes and microscopes. The science of elasticity may be as effectively studied with the 60-ton testing machine on the materials of construction as with pound-weights on the rods and wires of the physical laboratory; thermodynamics is, perhaps, as instructive a science when illustrated on

*Pure and technical science*

the steam- or gas-engine as when a diagrammatic air-engine appears on the lecture-room table; and there is a reality about the inertia of machinery in motion which illustrates momentum and energy in a somewhat more convincing way than the falling weights and the rolling balls of the academic mechanical laboratory.

We have diverged here far beyond the humble limits of our craft-school, but it seemed necessary to insist once and for all on the great principle: that technical instruction can be scientific in the best and highest sense; scientific method can be inculcated and illustrated on the material and apparatus of any special craft or employment as well as with the costly buildings and delicate apparatus now demanded for academic purposes. If it be said that apprenticeship is the true craft-school, the argument is valid, so far as many facts and empirical rules have still to be learnt in the shop, on the farm, or at the bench. But our secondary craft-school is to be preliminary to work in field and factory, it is to inculcate what the master or fellow-workman has not the time, nor usually the power, to do, namely, to emphasize the importance of intelligently following out each craft-process. The secondary craft-school must inspire its pupils with a desire to know the reason for the rote which apprenticeship is sure to thrust upon them. The secondary craft-school is not to be too specialized—at least not in rural districts; its pupils must spend much of their time on the farm, in the local factory, in the carpenter's shop, and at the smithy. They should not be required to learn the elements of

*Apprenticeship and craft-school*

mechanics out of examination text-books; nor be pushed on to the extraction of cube roots, as if that were the crowning feat of mathematical instruction. Let the pupils measure a plot of garden ground intelligently, the capacity of a barn with reference to the size of crop it will hold, or the cubic feet of air in a stable or stall with reference to the air-space necessary for healthiness of cattle; the approximate amount of half-inch planking to be obtained from an unfelled tree (to be tested after it has passed through the local sawmill)—these and many other exercises will occur to the intelligent teacher. Let his or her work be supplemented, too, by occasional lessons from the highly-trained artisan, the carpenter or millwright, the head-gardener, the shepherd or the dairymaid, or from the workers in any other crafts which are locally available and offer craft-workers of experience. The intelligent craftsmen may be scarce at present, but as the secondary craft-schools pass more and more of their pupils into local activities, and possibly keep touch with them through the higher craft-schools, through continuation and night-schools, the material to draw upon for occasional lessons, and possibly for permanent teachers, will become more extensive and better.

*Urban craft-schools: present chaos*

In the town districts the secondary craft-schools ought to be more specialized; some of their work is already being done by so-called technical schools and polytechnics. But these places and their courses are largely chaotic at present. They have not settled whether it is their function to give secondary craft-

education to boys and girls, to give higher craft-education to the non-commissioned officers of industry, to train the commissioned officers themselves —the proper work of the higher technical colleges, —or to provide cheaply a one-sided and, in nine cases out of ten, inferior academic education for young men and women who believe their success and standing in life will be assured if they are hall-marked with a university degree. It cannot be too emphatically asserted that absolute differentiation in function is essential for success in technical education, especially in urban districts. There must be secondary craft-schools which will supplement primary education, by illustration of scientific method on the elementary processes of most forms of labour. Boys and girls will leave these schools not later than thirteen to fifteen, roughly prepared to follow intelligently the lower grades of industry. There must be higher craft-schools, with much more specialized instruction, for the non-commissioned officers of industry. There must be technical colleges for the leaders of industry, and universities or university-colleges for pure science, literature, and other types of brain-work; these again must be supplemented by professional schools for medicine, law, actuarial training, etc. etc. There must be for the most capable pupils a possible passage from secondary to higher craft-school, and from the latter to the technical college, or in special cases, where pure scientific capacity is noted, a transition to the university. But the nation which fondly imagines that one class of teacher and one building will serve for all these diverse purposes, and calls it a polytechnic or a university-college, is

only excelled in folly by the nation which clubs a dozen such hybrid institutions together and supposes that they form a working university! Such a nation has not learnt the *principia* of educational theory, and the sooner it learns from the nations that have, the better for its welfare if that depends upon industrial efficiency. The secondary craft-school, the higher craft-school, the technical college, and the university serve quite diverse functions, educate for different careers and occupations in life; if economy or convenience bring any two under one roof, then there should be a differentiation of teachers; if even this be not possible, there should be at the very least a differentiation of material and of plan of instruction[1]. Otherwise, there is the greatest danger that instead of intelligent workers in the ranks, the secondary schools turn out a superfluity of incompetent non-commissioned officers; the polytechnics provide non-commissioned officers who know only the duties of the subaltern, and the colleges subalterns with the making of pure scientists, but not of technical leaders.

*Scope of secondary craft-schools*

In urban districts, from the higher grade or continuation board-schools, and from one side of the polytechnic teaching, must arise the perfectly distinct secondary craft-school, educating boys and girls to be intelligent workers in the ranks of specialized in-

[1] To give a man control of a higher craft-school because he has taken a brilliant university degree in pure science is a common illustration of the present chaos in technical education in England. It is hardly excelled by the offers of *teaching* posts which the high wrangler receives the day after the appearance of the class lists.

dustry. It must go no further than the attempt to show that all forms of manual labour can be performed intelligently: its aim is the real, or at any rate the idealized, craftsman of the Middle Ages, the man who loved his work, because he realized the why of it, and its relation to a greater whole. There is no doubt that the highly-differentiated character of some branches of modern factory labour—by no means all—tells against intelligent craftsmanship. For this reason the secondary craft-school must not be too specialized, even in urban districts. The demand of the state for intelligent citizens is equally important with its demand for intelligent craftsmen. Hence it should be a *sine quâ non* of every craft-school, whether secondary or higher, that each pupil should study one branch of pure science, or one literature, or one historical period, apart from his technical studies, as a field for rational enjoyment in adult life. Let it be done as recreation, not as task; but let its effectiveness be a condition of any state or municipal support to a craft-school. It has been in the past such a noteworthy characteristic of the British race to produce amateurs, following professions, trades, or even handicrafts, who have done first-class historical or scientific work, that we may hope that the absolute need for differentiation in education and the specialization of the smallest branches of knowledge will not finally check this production. The encouragement in the craft-schools of a special recreative study might be of most material importance in this direction. If care be taken that not facts and formulæ, but the scientific method and spirit, are illustrated on the

subject and appliances peculiar to the craft, very little time or energy will be expended in merely applying the notions of scientific observation and reasoning thus obtained to the recreative study. In the higher craft-schools and technical colleges, lecturers of the university-extension type would find a most useful field for their energy and enthusiasm in teaching recreative branches of literature or science, and above all in showing the pleasures of a library, apart from its value as a store for facts and formulæ, its most important function on the technical side. In the secondary craft-schools, also, the "citizenship" teaching should certainly be carried a stage further: both boys and girls should learn a little, if only a little be possible, of the reason for and history of the institutions—national, municipal, and social—which, as citizens, they will have to work under and develop.

*Athletics in secondary schools*

Lastly, in no secondary craft-school ought the need for athletic exercises to be disregarded. The anthropometric record of the primary schools should be continued, that it may serve as a control for comparative physical progress. But a certain portion of the time devoted to athletic exercises should now be applied to developing qualities which may hereafter be of service for national offence or defence. The rural lads should be taught the elements of drill, rough road-making, the ready use of pick and shovel, and the fun of scouting games; where possible, rifle practice should be introduced, and swimming and even riding be taught. For the lads of urban secondary schools some of these matters are difficult

enough; but the plan of holiday camps in the summer may be widely extended[1], rough map-making and scouting can often be practised on suburban heaths, and opportunities for drill and swimming, rough carpenter's, saddler's, or shoemaker's work can nearly always be found. In all these cases let it be recognized by the lads themselves that these things are not craft-training, but are taught to fit them for duties which a strong nation demands of all its citizens in one form or another. In the case of the girls the horizon must appear somewhat narrower, and it is, perhaps, only their teachers and elders who can realize the national importance of those forms of physical training which may aid them to be the healthy mothers of a strong race. Still it is highly important that they should realize that they belong to a larger whole: that they have a function in the state as well as a relation to individuals. Bandaging, first-aid, the elements of nursing, the care of infants —and of the aged—may all be taught as extensions of household economy, and the social value of such work inculcated. But they are not essentially outdoor physical exercises, and the latter, whatever be their real import, must bear for the girls the aspect of mere games, not of sports obviously directed to national ends.

To sum up, then, our conclusions as to the func-

[1] The camp-holiday system, which has flourished a good deal under voluntary effort during the last few years, ought not only to be developed and widely extended, but supplemented, if possible, by short summer cruises on training brigs, where the lads would receive a different kind of drill and learn a little, if the veriest little, of what the sea means.

tions of the secondary craft-school: it is intended for the rank-and-file workers in all the industries and crafts of the country. It should provide: (i) Training for the intelligence, by illustrating scientific method upon the material and appliances of every craft. As the elements only of the craft will be considered, many crafts will be combined in one school, but greater specialization may be possible in urban than in rural districts. (ii) Recreative Studies, (iii) Citizenship Course, and (iv) Athletic Exercises. The bulk of the instruction will fall to the lot of the permanent teachers under (i); subjects (ii) and (iii) may well be undertaken by a specially trained class of peripatetic teachers; while (iv) might largely be aided by volunteer workers, whose labours should be guided and systematized by district advisers, who would travel from school to school, suggesting and organizing the service with a keen eye for local possibilities.

*General functions of secondary craft-schools*

If from the secondary education of the rank-and-file workers we turn to that of the leaders, we have at once the differentiation into the two classes of non-commissioned officers or foremen, and of the commissioned officers, or the leaders of industry, the brain-workers, thinkers, and educators of the nation. Probably the first class will be largely drawn from those who have shown marked capacity in the secondary craft-schools; these should be passed on to the higher craft-schools, the work of which will be dealt with later. When we consider,

*Secondary education of middle classes*

however, the provision hitherto made for the nation's intellectual leaders in the matter of secondary education, one is surprised, not that the nation has gone relatively backward, but that it has survived at all in the keen competition of modern times. A nation needs organizers, leaders, thinkers, not only in commerce, but in manufactures, the technical arts, transit, colonization and exploitation, pure science, professional and literary pursuits. Up to the immediate present hardly any secondary education at all has been provided suitable in the least degree for a college training in any one of these matters except the last. Our commercial and technical leaders have rarely had any scientific training at all; they have grown up without it, and held their own owing to the political and economic conditions of their country relative to its rivals. Such will be an absolute impossibility in the future, now that the equal or superior sources of power of our rivals are being worked, and the plant is created and the labour trained which is requisite for production. Granted that resources and machinery are alike,—they are now far from being in our favour,—it is only the most highly trained intelligence which can turn the balance to our side, or even equalize it. Yet what has happened? The movement for technical education has led to the establishment of a number of technical colleges, where a more or less efficient technical higher education can be obtained, but it has not provided the essential stepping-stones to this education: namely, secondary schools up and down the country specializing in commercial, technical, and scientific

instruction. Occasionally the modern side of a large school may be found doing good work, but its existence at all is an exception, and it is an exception among exceptions if it gives a training useful for technical purposes. A Cambridge wrangler, who teaches to an occasional student an arid text-book on the calculus, with a view of his getting a scholarship; academic laboratory work of a physical or biological character, boiled down and sterilized to suit the youthful digestion; formulæ from algebra, facts from mechanics: all these exist. But in nine cases out of ten no direct and conscious training in scientific method, no teaching to observe, classify, and reason on facts collected by the lads themselves[1]. No specialization by *trained* teachers for commercial, technical, and scientific pursuits is in the majority of cases thought of; and since it would largely have to be provided by men not educated in the ruts of the older academic methods, there is small doubt that both teachers and taught would be looked down upon as of a lower caste. Desirable as it is to associate lads who are about to follow very diverse callings in life, there is small hope of efficient secondary education, specialized for commercial, technical, and scientific pursuits, being provided in the majority of our

[1] Every teacher in a technical college knows well the average public-school lad: personally delightful, athletic, popular, he cannot draw, his geometry is a rapidly disappearing acquaintance with Euclid I to III, his algebra a formula for quadratics, and his arithmetical accuracy sadly inferior to that of a shilling slide-rule. His secondary education has to be undertaken over again, and even then he will probably end in the South African Constabulary.

great public schools, with their traditions and systems centuries old. These modern schools will have to be founded *de novo*, or developed out of the large day-schools of urban districts, or the decadent rural grammar schools, which up and down the country may be found, atrophied under a system which was, perhaps, a vigorous reform in the second half of the sixteenth century, but supplies no urgent national need of to-day. Let there be no doubt, however, about the nature even of the commercial education we are considering; it is not intended to turn out commercial travellers and clerks, who fall into the class we have termed non-commissioned officers. For these the secondary and higher craft-schools should provide. The scheme is intended for the leaders of industry, for the men who will be manufacturers, merchants, shippers, engineers, the organizers and thinkers. These are the men who will pass on to the technical colleges and the commercial universities of the future. As the German technical universities[1] draw their students from the *Realschulen* and not the *Gymnasien*, so our technical colleges need an effective technical and scientific secondary education antecedent to their work. We have the German

*Need for modern schools*

[1] The German *Polytechnikum, technische Hochschule,* is not for a moment to be confused with our polytechnic, which ought to be a higher craft-school and is a hotch-potch of a dozen stages of education. It corresponds more to our technical college, but is ten times as complete. It usually represents the complete technical university, and by government decree its teachers and students are placed on an academic footing.

experience to draw from and to learn from, and we ought to be able to create schools which will turn out a lad with all the healthy traditions of English public-school life, but who has replaced its classical education by an effective training in the methods, not the results, of scientific inquiry.

*Functions of modern secondary schools*

To the general outline of these schools much that we have said of the secondary craft-schools will apply. The teaching will have to a considerable extent to be specialized—commercial, technical, and purely scientific departments being provided with different teachers and methods. In each case the primary object will not be to give the lad information useful to him in his future calling, but to develop his intelligence by the application of scientific method to the material and processes with which he will later be concerned[1]. Again, to prevent narrowness we must have the recreative study; and to strengthen social stability, the citizenship lessons. Athletic exercises, culminating in some knowledge useful for purposes of national offence or defence, must not of course be omitted. But as the secondary education of the classes we are considering will last at least two or three years longer, the extent of these secondary studies can be considerably increased. Thus the

[1] One man may learn how to use his reasoning powers from a teacher who adopts Greek grammar as his medium, another from a teacher whose material is provided by the hedgerow, and the powers gained in either way may be turned from one to another subject; but there are obvious advantages in selecting for the object-lesson material at least akin to what the reason is ultimately to deal with.

groundwork of a true culture—the superstructure of which must always be self-culture—can be laid in the technical college or science school. An important addition, however, should be made to the teaching of such modern secondary schools, not as part of the recreative but as part of the bread studies,—a reading knowledge of one, and a speaking knowledge of a second language should be insisted upon. The doorway into another race's scientific laboratory, its methods of work and of expression, is as important an opening for the mind as the doorway provided by a knowledge of its language into its institutions, literature, and folk-feelings. To grasp how a great investigator works needs presence at his lectures or in his laboratory, or at least the study of his papers,—it is an education which can never be obtained from text-books. In any specialized branch of science there are rarely at any given epoch more than two or three master-minds, and these are diverse in country and in tongue. To follow these personally or in the written word is an impossibility without linguistic knowledge, and science-abstracts and text-books are a deadening and nigh worthless substitute for direct contact with a master-mind. We shall insist later on the national importance of the *Wanderjahre*, but to profit by such years the young apprentice must have received in his secondary school the groundwork of at least one language, and maintained and developed that knowledge at college. The pure scientist or the professional engineer who cannot directly study the work of contemporary foreign investigators is most heavily handicapped, and in many cases a tenth of the

time and energy he will spend in finding out how to do things already done would have given him a reading knowledge of foreign literature. The speaking knowledge of a language serves a different purpose: it is essential to the pioneer in commerce, exploitation, and transit[1]. Started in the secondary school, it may be completed in the *Wanderjahre*; it is a practical instrument of a man's calling—like the multiplication table, he requires to be sure of it, but he will not, like the philologist, make it a means, in the first place, of intellectual training.

*Nature of teachers*

It would be out of place here to give even outline curricula for the secondary modern schools we have in view. If the curriculum of the secondary classical school has only been crystallized out in the course of many generations, no new scheme for science schools will in itself be wholly satisfactory, or work without initial difficulties and friction. In the first place, the teachers, to do the work effectively, have largely to be made. In the next place, parents have to be convinced that the secondary modern school is not going to provide knowledge useful in professional life. It is going, like the classical school, to develop the intellectual powers, but it will take as its material not the dead languages, but the living sciences which

[1] While French and German for the English-speaking races are the more valuable languages for the storehouses of method and knowledge they throw open, Spanish and Dutch are perhaps at present most useful for pioneering. But it is nationally important to have a great range of choice in the spoken languages among workers in both the commercial and technical fields.

bear most closely on commercial or professional work. There will be, undoubtedly, specialization and differentiation. The biologist and the physicist receive their intellectual education in observing and reasoning on a certain class of facts—they need mathematics as an instrument of investigation. The mathematician who insists that they shall have it as an intellectual education only is going beyond his legitimate sphere. In the same way, the engineer receives his intellectual training in a field very unfamiliar to most physicists and mathematicians, and the teachers of mathematics and physics who insist upon these subjects being taught to him as intellectual exercises from the pure-science standpoint are the bane of technical education. Secondary schools, like the higher craft-schools, will do little to improve technical instruction if this point be not kept in view: the teachers of pure science required for the technical side must be men trained in a technical college, and having touch with the needs of practical life. Such men ought to be distinct from the teachers of pure science on the science side, who ought to be men who have been through research schools and laboratories, and whose first aim will be pure science as an education, not as an instrument.

*Secondary classical schools*

Lastly, if we consider the secondary education given in the public and large day-schools as they at present exist, in many ways well fitted, perhaps, for professional and literary careers, we can only hope that the opening up of large secondary modern schools, turning out pupils of equal intelligence and

better fitted for modern commercial, mercantile, and technical pursuits, will serve as a stimulus to quicken and, above all, humanize their activities. They will certainly decrease in number, but this does not necessarily mean in efficiency; and where the endowment allows of a complete duplication of staff and educational apparatus, the running of modern and classical schools side by side would have all the advantage which the admixture of men of different callings, modes of thought, and social standpoint provides in after-life. Before the renascence, teachers of the old monastic learning would have denied that it was possible to improve their methods, or to change with advantage the subjects taught. Yet within fifty years the Humanists reconstructed the school-education of all Europe. They achieved it by raising an enthusiasm in youth, which demanded that instruction should be for both teachers and taught a vitalizing process and not a drudgery. A small minority of teachers with the new ideas, and a widespread rebellion of the taught, swept the old system and its professors swiftly and forever away. The abuses of to-day do not perhaps justify, nor the tutelage under which young people now stand[1], permit of quite such a drastic reformation. Yet the pressure of competing modern schools ought assuredly to modernize classical and philological studies. We want to train the in-

[1] In mediæval times the lad of fourteen to seventeen might wander across Europe seeking for the school reputed for its methods, or attracted by the vigorous teacher. The *Wanderjahre* for the schoolboy are, perhaps, wisely abolished; they will, let us hope, be reinstituted for the undergraduate.

telligence of each future citizen to observe and reason about facts, and this power can never be fully developed when the material dealt with is isolated from all relationship with present experience or living modes of thought. The scholar has to realize that he is merely a unit in a living nation, which is one among many nations, each with a history of its own. The study of a special literature or language may be very harmful if it is not seen in perspective. It leads to the spirit which supposes that philosophy was summed up in Aristotle, that style culminated in Cicero, that there is only one great religious work, and that Euclid provided once and for all what is needful for geometrical instruction. Comparative history, folk-lore, and custom,—the discrimination of what is peculiar and what is universal in the institutions of the special people studied,—are all needed if the scholar is to be saved from narrowness. The *Odyssey* is not only a great epic, it is intensely exciting as an object-lesson in the early stages of civilization, in the growth of mankind from boyhood to adolescence. The institutions of early Rome are unintelligible without comparison with Teutonic, Slavonic, and even African folk-customs and religious practices. Style and taste are never to be despised; but what we want the cultured lad of to-day to understand is what man now is and how he has come to be what he is. The over-emphasis of one period, one literature, one art or language, may be dangerous if it tends to obscure the fundamental principle that man is the product of an evolution, under vital forces of which science knows something and is daily learn-

ing more. No nation was ever without rivals, moulding and modifying its development; no literature without a growth; no art or craft without an historic evolution; no human product, judged from either the artistic or intellectual standpoint, final. The schoolmaster who forgets these things is not truly preparing lads to be thinkers and leaders for the nation; the academic teacher who does not make them the thread of his exegesis will aid little towards the much-needed humanization of the older forms of study. Neither religious thought nor educational theories can stand aloof from the growth of scientific knowledge. One and all react upon each other. We cannot stand now where Virchow did in 1877: the pressure of foreign commercial competition has been a conclusive object-lesson in the survival of the fitter. We must base national education on the need for national reaction against a changing environment; we must consciously prepare for the struggle, and by an intelligent study of human evolution arouse the patriotism and race pride of the young to assist directly in developing their intelligence for national ends.

*Higher craft-schools*

Before we pass to the specialized college education, a word ought to be said of the higher craft-schools, which should supplement secondary craft-schools in the preparation of the non-commissioned officers of industry. Hitherto these schools have either been wholly wanting or supplied by private enterprise bent on personal profit. The keynote to such a school should be intelligent instruction in a craft suitable

to lads of fourteen to seventeen who hope to be foremen workers. It should lay more stress on technical knowledge than the secondary craft-school, where the development of the intelligence is the first requisite; but it must, like all true education, appeal to the reason as a guide. It must also be far more specialized. We need higher craft-schools in plumbing, farriery, cabinet-making, textile industries, metal plate work, and a dozen other different things. As usual, we began with the wrong end—establishing examinations in these subjects, rather than model schools. Nor have the so-called polytechnics and technical schools of the county councils—good although the work has been in *some* cases—wholly made up the leeway. The technical school or polytechnic, instead of throwing itself body and soul into a special branch of craft or industry, has aped the university. It prided itself on getting a few students labelled B.Sc., or on producing a small piece of pure-science research having no bearing whatever on the national industries. It aimed at turning out second-rate engineers, rather than first-rate machinists. The result has not been, and cannot be, that great increase of craft efficiency which we might expect from the amount of money expended on technical education. The polytechnic may become a centre for a mild form of general instruction and amusement, or it may become a specialized higher craft-school. It cannot effectively fulfil both functions. In the first case it will probably fail, as the mechanics' institutes of last century have failed; in the second case it will become not only of local but of national importance. Let one

technical school devote itself to smith's work, another to the printing and lithographic arts, a third to the glass industries, a fourth to bookbinding, and so on[1], not duplicating their work and teaching many things superficially.

*Need for local specialization*

Some large towns may maintain a considerable variety of specialized schools, but it is the student who ought to wander; repetition of staff and teaching material at a dozen centres means waste and inefficiency. If Birmingham founds a higher craft-school for electroplating work, Wolverhampton may reply with a metal-plate-work school; if the Whitechapel higher craft-school specializes in cabinet-making, Clerkenwell may find a wide enough sphere in the glass trades. The bane of technical, indeed of all education of an advanced kind in England, is the unreasonable overlapping of institutions, teachers, spheres, and methods. The higher craft-school has nothing to do with academic training, therefore we appoint academic scientists to teach in it, and place them on university faculties; the technical college has a separate but coequal function with the university, therefore we mix them up, thinking one method of teaching and one teacher will serve for both. We send peripatetic teachers out to fulfil the all-important function of raising the general culture of the people: we fancy it academic extension, and

[1] To some extent this has been begun with the textile schools in the North of England, and the photographic and optical instrument schools in London, but these are the merest beginnings only.

demand that it shall lead to a university degree. Nay, a degree having come to be looked upon as a mark of caste or gentility, the branding-iron is, in the true democratic state, to be brought to every man's chamber. At the basis of every science are real philosophical and intellectual difficulties; in its structure, endless lessons in observation and in method; at its summit, the prospect into still untrodden lands. Not one of these things can be indicated by an examination schedule; they are scarcely touched by any text-book which follows such a schedule. They are appreciated only when the student comes into personal contact with the creator of knowledge, and sees how he observes and reasons. Here is the field of true academic work; no branding-iron brought to a man's chamber can testify that he has been in contact with this vivifying atmosphere. Nor can we bring science and learning in their highest expression to each student's door. He must go out on his *Wanderjahre* in pursuit of the master-teacher, or of the school which has specialized in his chosen study. What is true of the university is equally true of the higher craft-school: the student must seek the specialized teacher and the specialized school, and not trust a local polytechnic to be an effective educational *omnium gatherum*.

*Higher commercial schools*

Besides schools for the more mechanical crafts, we need higher schools for the lower ranks of head-workers, for the lower branches of civil and municipal employ, for shorthand and clerks' work, for postal, telegraph, and railway service. Some of these em-

ployments—where students will pay to be got through an examination—are at present provided for by private enterprise. But such schools want organizing as a comprehensive system, and should not be based on the question of immediate profits derivable from some small section of the work. To such schools the government, the municipality, companies, and private employers would very soon learn to turn for a specially-trained class of employee, and we might hope in the first place that they would definitely replace the Chinese system of selecting by examination.

*Higher education*

We now turn to the highest forms of education, which, whatever we may hope for in a distant future, can at present only be organized for the brain-workers of the community—for its thinkers and leaders. Here we find much the same educational chaos as we have had to note lower down in the scale. With as great, if not greater, need for it, there is even less organization and specialization. As a first classification, we may consider our subject under four headings: (i) the university proper; (ii) the technical college; (iii) professional schools; (iv) the commercial university. How far these four phases of advanced education can be advantageously united into a single university system is not easily determined. In Great Britain the advantages of union are: first, that as education becomes more specialized, the larger funds accumulated during many generations for the university proper may be shared by the younger branches of

study[1]; secondly, it is of immense gain that both students and teachers of specialized studies should mingle together, and share traditions common to all. This is what must take place in later life, and the joint university provides, from student to professor, an excellent training in toleration,—a characteristic as important in science as in theology. On the other hand, the union of the four schools in one locality and institution is likely to disguise the absolute need for entirely independent staffs, and for completely specialized methods of study. The doctor and the engineer both require mechanics and chemistry, but to teach medical and engineering students in the pure-science laboratories of these subjects is an evil only sanctioned by absolute want of funds, and solely due to the haphazard growth of British systems of education. Look at the specialized staff of one of the great German polytechnics,—a dozen professors and double as many more lecturers and assistants,—and then compare such a staff with the roll presented by any university or technical college in Great Britain! Nine out of ten of these colleges think it sufficient to provide a so-called professor of engineering, and send their students to pick up what mathematics, what physics, what chemistry they can under teachers who have had no special technical training, who have never studied the special needs of engineering students, nor published a single memoir dealing with technical problems. The result of such a

[1] Thus it is satisfactory to hear of College fellowships at Cambridge being given to engineering students for technical dissertations.

system is manifest: we have no research in the sciences preliminary to engineering; not even first-class text-books, for the preliminary science teachers in the engineering schools are, if not overdone with teaching, workers in pure science. It is very little better in the matter of engineering research pure and simple. The professors are not able to specialize, partly because they have to teach too many subjects, owing to want of colleagues and of the fitting secondary and preliminary scientific training in their students, and partly because they have not been themselves educated in an atmosphere of research. We do not think there is exaggeration in this statement of the case; we have not overlooked certain text-books on the strength of materials, machine-design, or the steam-engine. Rather these illustrate our text: they show that want of knowledge of the modern theory of elasticity, of kinematics, or even of contemporary foreign work, which indicates how pressing the need of an effective research training may be in even the highest places under our present system.

*Technical colleges*

We are undoubtedly far better off now than we were a generation ago; the technical schools up and down the country are doing good work, but they are not in any case comparable with a German polytechnic, nor with the technical university which we must hope to see ultimately established here. The University of London, for example, comprises three or four engineering schools, each duplicating much preliminary work; combine their staffs, specialize their individual

teachers, give them leisure and laboratories suitable for research, and there would be only the foundations of one real technical university. Yet no other university or technical college in the country could produce as much. We have started again on the wrong system—multiplication of little centres, doing their individual best no doubt, but not what is best for the nation. Three or four technical universities would suffice for the whole nation, but we have established fifteen or twenty technical colleges, on the theory that knowledge, like milk, must be delivered at each man's door. The result is that all the schools are, broadly speaking, doing the same elementary work, and there is no specialization. No one school devotes itself entirely to civil engineering, naval engineering, hydraulics, municipal work, gas, electric lighting, or haulage, etc. etc. The elements of many things are touched on, but the higher teaching and the atmosphere of research are largely absent. What then is needed?

*The technical university*

The development of three or four only of the technical colleges of the country into technical universities, with specialized departments of mechanical, civil, electrical, etc. engineering and of chemical industry. The remaining schools should disappear or be converted into higher craft-schools. Use their staff or buildings, where possible, for special departments of the university, but recognize once and for all that under the stress of modern competition these are matters of national importance; and that to bring our technical intelligence up to the level of that of

our neighbours, we do not want local engineering professors, or local colleges, but national technical universities, each with ten or more complete laboratories, a score of special technical professors, and with equipment and funds comparable only with those of the whole of the pure-science faculty of a first-class modern university. Such universities would train not only the nation's industrial leaders, but the teachers for the secondary and higher craft-schools; and by bringing both classes into touch with actual knowledge-making, indicate on the one hand how the problems of practical life, on the other the problems of craft education, may be met and solved.

*The university and its future*

If we pass from the technical university to the university proper, by which we are to understand the corporation of teachers which deals with training in pure science or pure scholarship, without regard to the needs of special industries or professions, its work in the future seems likely to become more specialized. There will always be minds for which the best intellectual training, independent of future calling, will be an end in itself. Senior Wranglers may make good judges; senior classics, excellent doctors; and double-firsts, capable statesmen. But in the case of modern nations specialization of the individual appears to be a progressive feature, and as soon as it becomes a recognized principle that the intelligence can be trained and developed by observation, and reasoning on observation, applied to technical or professional subjects, much of the monopoly value of pure academic studies will disappear. The study of yeasts may

be as good an intellectual training as that of the gases of the atmosphere; bacteria are as mentally exciting as snails; the vibrations of a bridge lead to more aspects of physical science than those of the tuning-fork, and examples may be multiplied to show that technical or professional education is not one-sided or intellectually inadequate. It seems likely, therefore, that academic studies, whether purely scientific, literary, linguistic, historical, or philosophical, will tend to be recognized more and more as a training for specialized careers, namely, for statesmen, scientists, historians, literary men, educators, and makers of all forms of knowledge,—in short, for the intellectual leaders of the nation. With this recognition, academic studies will become more intense and definite in character. Above all, the research training will more and more supplant the examination training. In actual life it is the problem which comes to us; stores of facts are accessible—we want the training which enables us to apply these facts and solve the problem.

*Reformation of academic studies*

The recognition of this fundamental fact is the reformation which must take place in academic studies. Examination is by no means the best process for testing the power to observe, classify, and reason on observation. The known itself may be made the subject of a formally new inquiry, and a monograph may be written showing data, classification, and deduction;—the method is equally applicable in physics, biology, or history. It forms the basis on which the capable instructor can point

out the sources of information, the proper method of arranging it, the logical results which flow from it. Scientific method, the true spirit of inquiry, is better learnt by criticism and suggestion applied to two or three such monographs by the master-investigator, than by months of labour devoted to learning the known for examination purposes. We cannot too often repeat that for the purposes of education what we need is a training in method, and not, in the first place, a mere knowledge of facts, nor even of the laws under which these facts may be classified. It is so easy to provide facts and formulæ, so difficult to give insight into method, that text-books, degree schedules, and examination papers invariably turn to the former; and the latter, to be learnt only from direct touch with the investigator or from the classical memoir of the master, is thrust ruthlessly aside. Treat the known as unknown, to be rediscovered, or bring the student rapidly to the real unknown on the confines of the discovered, then true training in method becomes a possibility. Every nation is daily being confronted with new problems; they may be material, or they may be social, or they may be intellectual. Admit progressive evolution, and this statement is an obvious truth. The nation's brain-workers, whether their rôle be great or small, have to be prepared to meet and answer these new problems. Training for examination is but feeble equipment, certificate of examination success very one-sided evidence of competence for this essential function in a nation's thinkers. Nor is the reader to suppose these remarks apply only to the training of

master-investigators in any branch of human knowledge; the academic training is that upon which the great majority of secondary educators depends, and their present failure to apply, or rightly apply, heuristic methods is largely due to the examination system not having brought them into close touch with the methods of research. Nay, our professional and commercial classes suffer in international competition from much the same want—definite training in observing and reasoning upon facts. The university of the future will bring its undergraduates, not into touch with an army of tutors and "coaches," nor with their impedimenta of examination schedules and text-books, but directly into the field, the library, the laboratory, where the material of knowledge is accumulated and classified, and into personal touch with the men who make it.

*The professional college*

The problem of the professional college or school of academic rank and its relation to the university is one of considerable complexity, and can hardly be dealt with at length here. Specialization is the most emphatic note of modern national development; it has to be met, not by protest, but by providing for training in *method*, even when a special or somewhat narrow class of facts is dealt with. The establishment of technical colleges for engineering, metallurgy, chemical industries, navigation, agriculture, and forestry[1] indicates to some extent the direction in

[1] In the last three cases the colleges should be for the scientific experts, not for mariners, farmers, and foresters, who require, in the first place, higher craft-colleges. What might

which the older academic faculties of law, theology, and medicine must develop. It is fundamental that the preliminary linguistic or scientific studies should be, as in the case of the technical colleges, in the hands of a special staff, distinct from that of the pure academic studies[1].

*The law school*

It is difficult to understand why great law schools do not thrive in this country. No other nation can present such living object-lessons in comparative law: it rules in different parts of the world under nearly every present or past legal system, and by innumerable forms of folk-custom, which exhibit legal institutions

be achieved in the science of navigation at present by an expert school can be well realized by a study of the first fifty years of Gresham College, London. The merchants and traders of London, in the first flush of new-world discovery, turned to Sir Thomas Gresham's professors for their instruments of, and treatises on, navigation.

[1] It is not to be inferred that mechanics or biology is to be taught by medical men waiting for a chance to get on to the clinical staff of a hospital school. On the contrary, we want a specialized class of teachers, who devote their leisure to research in biophysics and kindred subjects. The mechanism of the jaw is quite as good an object-lesson in the fundamental principles of mechanics as the screw and the systems of pullies, while the principle of energy and the laws of elasticity are subject to variations in living forms which are apt to be overlooked by the pure physicist. The range of linguistic studies required for canon and mediæval law, for *Weisthümer* and folk-custom, are scarcely those of the academic classical scholar or the Teutonic philologist. Nor does the university philosopher find anything profitable between Aristotle and Descartes,—although it was the age of fathers and schoolmen, who directly or indirectly gave rise to all modern European philosophico-theological systems.

in almost each stage of progressive evolution. Yet comparative and historical knowledge is very largely lacking in our practical lawyers; but few of them are acquainted with the French, Dutch, or German codes, or have gained insight by a study of the development of the early Teutonic and mediæval systems. The result is a want of imagination in our own domestic legislation, and too little sympathy in dealing with the legal institutions of subject or assimilated races. The law schools have thus partially failed to create the class of men needed by the nation for its legal work in all corners of the globe. The broad idea of satisfying a national want has not been a primary consideration, and to this extent they urgently require that humanization which is demanded in the history school, if it is to become a school of statecraft.

*The medical school*

Perhaps in the case of the professional schools the most complete chaos in educational matters is to be found on the medical side. In the first place, it cannot be doubted that the hospital system itself must soon suffer a profound modification. It is impossible that the present system of support by fluctuating charity can permanently continue. Alongside the public charities have arisen infirmaries, fever hospitals, and asylums supported by public funds, and in many cases but little used for clinical instruction. The medical schools thrive or not according to the success of their hospitals in attracting charitable subscriptions, and this again depends indirectly on skilful advertisement. The result is overlapping, rivalry, want of

specialization, and the predominance of pecuniary instead of purely scientific interests. General municipal control of the whole hospital system must sooner or later be the rule, and with the wider clinical material thus placed at the disposal of medical instruction must come a diminution in the dominance of individual medical schools over individual hospital management. The overlapping of the preliminary teaching, and of much of the more theoretical and scientific branches of medicine and surgery, must be avoided. The direct and sufficient payment of all forms of medical teaching must attach men to academic work and experimental medical research as a profession, and such teaching not be undertaken as a step to a consulting practice. The competition of the medical faculties of different universities, and of the medical schools of the same university, would be perfectly healthy if it depended solely upon the reputation of the teachers; but it depends largely on the flow of public subscriptions to individual hospitals, the success with which the school may be used as a step towards a professional reputation, and the skill of one or two men in effective advertisement of the special wants of their individual hospital, or its special fitness to deal with a disease for the time looming large in the popular mind. The municipal control of the hospitals, the utilization of all clinical material, the wider separation of the academic teaching of medicine from its purely professional pursuit —these are the points which arise in the mind of one who views the present chaos from an outside standpoint. But if the observer be an outsider, he is a

sympathetic one, who believes largely in the academic future of experimental and scientific medicine. Yet here the very instruments of knowledge (such as vivisection) and of experiment (like inoculation) demand the most careful and diplomatic procedure. The storms of the past in these matters are as nothing compared with what we may experience in the near future; and if sure progress is to be made, there must be no hasty adoption of tentative treatments, when no strong scientific arguments in their favour are adducible; there must be no "fishing" inquiries on living forms; in other words, each experiment sanctioned must be directed to answering a definite question, which in the opinion of scientifically trained minds there is reasonable hope might be answered by the investigation proposed, and, if answered, would be of substantial service to medical or surgical treatment. Lastly, a greater knowledge of the nature of scientific method and of scientific proof must in some manner be provided for by academic medical training[1]. Medicine, and even surgery, must to a large extent be, and remain, empirical; but it is just the empirical sciences in which, for example, an accurate theory of statistics is of most

*Need for scientific method in medicine*

[1] In the course of the past twenty years the writer has received a scarcely intermitted flow of papers and letters from pseudo-scientists, circle-squarers, perpetual-motion mongers, heredity-theorists, neo-Darwinists, and others. The common feature of all these productions is the failure to grasp the elements of a really scientific *proof*. If the authors were classified by profession, the general medical practitioner would lead in numbers, the engineer being second, and the theologian a comparatively poor third.

importance. It is not too much to say that medical statistics are at present in a most rudimentary condition; definite conclusions are over and over again drawn from short series of cases, where the trained statistician realizes that the emphasized differences are well within the limits of random sampling. Or, again, A and C are found statistically to be associated with B, and it is argued that A and C must be themselves associated. The recent vaccination legislation has produced most instructive object-lessons in this direction. It has very unfortunately created a large class of men with pecuniary interests in the maintenance of vaccination. These men have had, in the press and at public meetings, to face a strong opposition, partly sceptical, largely fanatic. Is it not too much to say that from the standpoint of science the medical defendants' handling of statistics has been excelled in inadequacy only by that of their opponents. Much of the strength of proof in medical science depends entirely on statistics; copious raw material can be obtained from hospital practice, but this is rather too largely drawn from special classes of the community. The bulk of data from all classes either escapes written record, or remains "unstandardized" in case-books; here it is monopolized by the individual as "experience," when by co-operative action it might be statistically generalized into proof. The quantitative value of the correlation between environment, age, or physical characters and the special features or virulence of any disease is probably unknown at the present day in a single instance; and yet it is hard to conceive that clinical prognosis would

not be greatly advanced, especially among the younger members of the profession, by a quantitative knowledge of this kind. An authoritative body standardizing records, collecting individual experience and reducing it by adequate statistical theory, seems almost a necessity for medical progress at the present day. An elementary training in the handling of statistics and an insistence on the nature of scientific reasoning and statistical proof seem urgent needs, which ought to be, but are not, provided for in the preliminary scientific education of the medical profession.

*The commercial university*

Passing from professional schools[1] to the commercial university, we see at the present moment a great experiment being made in this direction. Birmingham has wisely entered on an unoccupied field. It may be desirable that one or, at most, two large centres should follow its lead, but it is most sincerely to be hoped that every university and university-college in the kingdom will not now appoint a professor of commerce and advertise a commercial department because they think it will pay. They have neither the funds nor the experience requisite for success. What is needed, from the national standpoint, is at most two or three perfectly efficient, fully manned, and fully equipped commercial universities,

[1] The range of professional schools wants considerable widening. One profession certainly ripe for a great professional science school is that of the actuaries, and a little study of official reports will show that a school for government statists is a necessity of a not distant future.

attracting students from the whole area of the empire. There are plenty of unoccupied fields for other institutions and colleges to specialize in, to the national profit, without the creation of innumerable small rivals in a new sphere. This is, of course, on the supposition that those who have first taken the work in hand will do it thoroughly, even if their progress be gradual and tentative at stages. Let it be remembered that it is not a mere professor of commerce that is required, but ultimately a staff of ten or a dozen such, with a large auxiliary force of lecturers and assistants. The man who can effectively deal with preferential tariffs and the general fiscal policy of the empire is not necessarily the man who has special knowledge of commercial interests and transit possibilities in China. A fundamental rule of the commercial university ought to be the "third free year" of the Russian academic system, and this means that only two-thirds of the senior staff will at any given time be actually engaged in teaching. The "third free year" is only free from teaching work; the lecturer is expected to travel for the purposes of research[1]. Owing to the rapidly altering, ever contracting and developing, processes of commerce, it will be especially needful for the teacher in the commercial university to keep in touch with current progress and methods. Nor can a man rear men to be pioneers unless he has

[1] Started in the commercial university, we might hope that this wise custom would extend to the pure-science, medical, and engineering faculties, where it is as important to seek new material, to test foreign methods, and critically to examine current practice as in commerce.

done pioneering work himself. It is a big task which the commercial university sets before itself, full of difficulties and, possibly, of pitfalls, but one of essential national importance to-day, when our commercial leadership has been more than threatened. We have to rear a new type of worker, who will see in trade not only a source of individual profit, but a patriotic duty. Developing commerce on the Yangtse, or struggling against fever in West Africa, or starting new industrial enterprises in the Argentine, the trader must realize the relation of his efforts and those of his colleagues to thousands of handworkers at home, whose bread must come from over the sea by exchange. He must recognize that on his intelligence, on his linguistic and local knowledge, on his readiness to adapt goods and transit to environment, depends, to a far larger extent than has been dreamt of in the past, the national fitness to survive. The leeway of the nation has to be made up by increased intelligence, first in production and then both in distribution and exchange; the former need has to be met by higher craft-schools and improved technical colleges; the latter, by the creation of commercial universities. Can any training help the nation to the skilful merchant and the fully-equipped pioneer? Those who believe in education and modern scientific methods can only reply: Yes, if you train the intelligence by the heuristic method, and exercise it on the materials of its future work. It is a great task which Birmingham has set itself; let us hope that it realizes its magnitude and difficulty—above all, that it understands that failure, from want of efficient staff or of equipment, or from lack of

internal or external enthusiasm, would be little short of a national disaster. It would discredit for years, if not indefinitely, the systematic training of intelligence in one of the most important fields of national activity.

*The Wanderjahre*

Commercial universities, again, suggest the great importance of further extending the *Wanderjahre* custom. We have already discussed the necessity for local colleges, schools, and universities specializing, and the advantage to the student of wandering in search of his subject and of the master-teacher. To the commercial university a relatively considerable number of studentships should be attached, the holders of which should be compelled to travel and report on foreign and colonial commercial methods and possibilities. These reports should in the first place be looked upon as exercises, but selected reports might well deserve publication as monographs of commercial research. Past holders of such scholarships, the pick of academic training, with their minds freed from insular method and local custom by the insight of travel, would undoubtedly be in constant demand for pioneer work. They would form a class such as is being rapidly formed in pure science[1] by the 1851 Exhibition scholars, men compelled to wander in search of research training. A percentage of failures there has been, and probably must be, but the next generation of physicists and chemists will undoubtedly show how markedly ad-

[1] Comparatively few of these scholarships appear now to be given for essentially technical research,—which was possibly the original intention.

vantageous has been the system. The *Wanderjahre* with the research studentship must be widely extended to all fields of work. Any Oxford or Cambridge college which insists on its fellowships being held only on *Wanderjahre* research conditions will quickly realize the profit which must flow from the increased reputation of its members and the broadened views and activity of its fellowship-lecturers. The older universities can distribute their fellowships without the special limitations set in the case of the 1851 studentships to which we have already referred: they could yearly send out men to study the flora and fauna of almost untouched districts; to learn the native languages, religions, and customary laws of British and other possessions; to study under the masters of pure science, history, or philosophy who exist outside their own walls; and to return, as the American travelling fellows have done from the European universities, to develop their home institutions and widen their educational system by leaps and bounds. Without such *Wanderjahre* training, no academic post ought to be open to the teacher of the future.

## III

## SCIENCE IN THE DIRECT SERVICE OF THE STATE

A slender sketch like the present does not permit of our dealing at length with another class of science school of vital importance to the state, namely, *Government Schools* training directly for special branches of state service. Here the maximum efficiency possible both in staff and equipment is absolutely essential for national safety, and yet the routine, almost a necessity, of official institutions is excessively apt to check just the very variations of individuality and the genius on which discovery in science and progress in its practical applications almost invariably depend. For this reason it is very desirable that the government schools should be limited to those branches of instruction which are needed only for the national service. For example, schools of offence and defence—naval colleges, staff colleges, artillery and military engineering colleges; to these ought probably to be added, schools for home and imperial civil service—for consuls, native state residents, and the lower branches of the diplomatic service. It seems, but for the historic evolution[1], a curiously anomalous

*Government schools*

[1] The origin of the all-pervading state-examination system in the United Kingdom was the desire to check nepotism in government appointments; to hinder one type of inefficient is not equivalent to selecting the fittest and training them effectively for their specialized work. Even the examination

process to select for many of the latter services men who have obtained examination distinction in classics and pure science, often taught by crammers, and with no special relation to the future work of the taught. It would probably be a great advantage to place these colleges, where feasible, near to one or other university. Thus while specialization in training and study should be insisted upon, both teachers and taught would have the widening influence of contact with other forms of work and play. The want of this "touch" undoubtedly tells on the efficiency of certain service colleges: their professors are too isolated; and necessary as is specialization, and valuable as is *esprit de corps*, the creation of a caste among the students, with caste habits and amusements, is far from an unmixed good. Without rivalry, and free from comparison with any but foreign schools, the government service school is liable to run in grooves; in many cases the staff does not appear to be numerous enough or sufficiently specialized to have leisure or inclination to study new problems or foreign methods. The pay of a government professor and the honour of the position should be such as to attract the highest teaching and organizing talent to the state service, and the leisure at present sometimes devoted to external teaching and examination work should be

system has probably been adapted, by artificial "adjustment of marks," to pass into the service not individuals, but types of men who appear best suited for the work in the eyes of certain commissioners. In other words, we are trusting very considerably to *personal* judgment as to a fit type; and this fact, be it good or bad, is screened behind a complex system of examination-marking.

monopolized for specialized research work in the national service.

Lastly, the government schools should be confined to those branches of the service where the specialized training required by government servants is not already being provided on an adequate scale by other educational bodies. A government civil engineering college, for example, may be perfectly efficient in its own line, but the men it turns out see only one group of teachers and one form of instruction. The whole service may thus run far too much in one groove, which would be impossible if its members were the picked students of the various technical schools and universities. The same criticism applies, if to a less extent, to naval engineering and architecture. The Admiralty, which occasionally does draw on external supplies, rarely gets the best students of the technical colleges, because it draws by an examination schedule which none of the more efficient engineering schools would be likely to adopt for its curriculum; and if they did, it would be, under present arrangements, devoting their energies to a small and very uncertain class of student. It would be an interesting experiment—and we believe a successful one—if the government gave for a trial number of years a limited number of engineering appointments to the pick of the technical college students, and compared their work with that of the men reared in their own schools[1]. We believe that the wider field of selection would lead to a greater

*Relation of government schools to technical colleges*

[1] This step has been taken since this paper was written in 1902.

variety in capacity, talent, and training being made available for the government service.

*Government research institutes*

From government schools we naturally pass to government research institutions, and the position of science as consultant in the modern state. The position accorded to science in the past in this respect has been a very defective one. The state needs quite as much scientific as legal advisers; indeed, under present circumstances, they are perhaps even more essential. Not only problems in offence and defence, but in development, transit, industry, disease, sanitation, reproduction, and medico-legal matters arise daily, and the government wants not only to know where to turn for immediate advice, but to be sure that it will get what for the great bulk of cases is *sound* advice. Beyond this, the progressive state ought always to be on the look-out for and seeking to encourage discoveries or inventions which will increase national efficiency either for war or in peace. Something of this latter function may be fulfilled by permanent government research institutions and consultative scientists. But not only is the incentive to discovery greatest in the young man with his future to make, but the power to discover great things rapidly diminishes with age. There is the born scientist, who researches for the keen intellectual pleasure of the work, and would go on, whatever his income or post; and there is the man for whom research or science is a means to a living and a position. He pursues it to a competency and to his

*The two scientific types*

D.Sc., to his F.R.S. or to his K.C.B., as the desire impels. He retires on his laurels, spending his life on committees, emphasizing the needs of pure science, the importance of technical education, and scaring us with the German bogy[1]. It would be unreasonable to condemn this man; for he belongs to the type which forms the bulk of humanity, whether occupied with science or any other pursuit. He has probably done good work, and his experience is of value for consultative, if no longer for research, purposes. We have only to remember that science has and can have no high priests, for it is always progressive and advancing. It is hardly too much to say that the moment a scientist reaches celebrity as a man, he has ceased to be a discoverer. For he can hardly attain fame before middle life, and already the younger man is on his shoulders reaching higher, for he starts with his elder's knowledge and with the unspent energy of youth. One of the greatest dangers of science, and especially science in the consultative service of the state, is the possible creation of a scientific hierarchy, resting on past achievement and believing itself at the summit of scientific knowledge. As soon as a man ceases to research, he has fallen behindhand; his tools grow rusty, and he ceases to grasp new methods and new possibilities. Hence one

[1] All honour to Germany's scientific work! Her specialist has organized his science and made research a trade, yet his product lacks too often the real insight, the lucidity, the touch of genius characteristic of the best French work; rarely, too, does the German break entirely novel ground, as was done by the three great scientists of the English type—Newton, Faraday, and Darwin.

of the greatest problems of the state is how to draw into its service not only those who have achieved as consultants, but those who are achieving as discoverers. Possibly an extension to our country of the French system of substantial pecuniary prizes, with not too-closely defined limitations, would turn more of the research work of the country to national ends. A prize every two or three years of four or five thousand pounds for a markedly useful contribution to the country's means of naval defence; a like sum for the most valuable work tending to develop the chemical industries of the country, or to improve its sea or land transit; or, again, equally substantial prizes for medical or sanitary discoveries—these would draw the energy of many youthful scientists into channels of national value. A yearly government offer, not necessarily an expenditure, of £10,000 to £20,000 in such prizes would be no extravagant sum, and might well have enabled this country to lead in at least some of the recent fields of discovery, such as smokeless powders, submarine boats, motor cars, wireless telegraphy, etc. etc. Such prizes and research should be independent of national laboratories and government consultants, to whom more specialized problems and routine difficulties should be submitted for solution or advice. In the one case the appeal is made to the energy of the youthful scientist, in the other to the experience of the consultant, to the store of current knowledge.

*Prize system*

Considering more closely scientific institutions in the direct service of the state, it will be found that

the ideas of men on this point are at present somewhat chaotic. Such institutions as exist have arisen partly from the immediate exigencies of executive, and partly from the outside pressure of pure scientists, asking for government assistance, or for public support on the ground of a private institution fulfilling a crying national need. This haphazard origin accounts for the want of organization and specialization; private institutions are partially doing national work, and national institutions which should be doing specialized industrial work have fallen to some extent into the hands of pure scientists. Here, as in other fields, a differentiation of pure and applied science is necessary. It is perfectly true that none can tell how soon a result of pure science will be applicable to industry; but the type of mind that can apply such results is rare, and the bulk of applied science problems are first formulated, and afterwards the extension of pure science which leads to their solution worked out[1]. In the first place, therefore, a nation needs laboratories for its industries—for standardizing the implements, testing the materials, and distributing knowledge with regard to the processes of its manufactures. There must be institutions which, free of every bias, will test and compare the products of all manufacturers seeking government contracts, or will advise Boards of Trade and state or municipal

*State science institutes*

[1] Of course this rule is not universal, but it is strikingly illustrated in pure and applied mathematics. Developments of pure analysis are now and then of occasional use, but pure mathematics have over and over again been enriched by analysis directly invented for the solution of special physical or even technical problems.

authorities as to regulations for factories, transit, food, and sanitation. These needs stretch far beyond any existing institution, and cannot be satisfactorily dealt with except by technical specialists having control of independent laboratories.

Thus the nation's wants comprise: (i) *National Engineering Laboratory.*—This must be subdivided into mechanical, civil, and naval departments. The first would test materials and machinery for government use, or apply standard tests in the case of corporations or private individuals. It should keep a hold on the industries of the country by reports on the quality of materials of construction bought in the open market, and their quality relative to foreign productions. It should undertake engine and other tests for manufacturers, and report to them on the relative efficiency of British and foreign machinery. In fact, in every way within its sphere it should apply and circulate current knowledge. The second, or civil engineering department, should deal in a like manner with docks, railways and general transit, water and sewerage, etc. It should be prepared to advise the government or municipalities on the conditions to be satisfied in bridge structure, to criticize development plans from the national and from local standpoints, to provide tests for dam efficiency, data for the flow of fluids, and a multitude of other matters which come daily before civil and municipal engineers. The naval department should lay down the conditions for testing the machinery of ships, the strength of their plating and riveting, and keep shipbuilders in constant touch with foreign developments, as well as

*National engineering laboratory*

help to maintain a high standard of efficiency in home work. It should assist indirectly or directly in the registration or classification of ships. Of course much of all this is done at present by various government inspectors or departments, by private corporations like the two Institutions of Engineers and Lloyd's. But it is not done in a systematic manner. When a pressing need arises, a commission is appointed, which investigates or experiments for a time on iron, boilers, or bridges. It has to do this in a more or less haphazard sort of way, with a temporary staff, and without a properly equipped centre, or even without direct experiment by comparing the conflicting evidence of too often interested witnesses. These defects of existing procedure result in grave delays, much expense, and general inefficiency. A trained staff accustomed to experiment, with apparatus and locus provided, ought to be at the constant service of such commissions; in many cases such a staff would be already prepared with the unbiassed information necessary for a judgment, and would be the centre from which government and private individuals could at once ascertain what was known here or abroad on the problems ever arising in progressive construction.

*Electro-technical laboratory*

(ii) In close touch with the Engineering Laboratory should be a *Laboratory for Electro-Technical Industries*. This is especially needful in the case of electric transit. But electrotechnology opens up such an immense field of activity in transit, lighting, telegraphy, telephony, power, and the smaller arts, that the laboratory ought to be differentiated from that for engineering proper. Here there is at present such

a wide amount of work necessary in standardization, testing, regulation, and control for public safety, that the early establishment of such a laboratory is almost more urgent than that of any other.

(iii) It seems almost unnecessary to discuss the importance of a *National Chemical Laboratory*. This is to some extent already provided for in separate government departments. What is needed is centralization, departmental differentiation, and complete and efficient equipment. It must be in no sense an institute for research in pure science, but it has to answer the innumerable chemical problems of the state, both on the organic and inorganic sides. It must do for the chemical industries what the engineering laboratory does in its own field—standardize, test purity, report, and watch foreign rivals; deal with colonial produce, poisons, adulteration of food, and an infinity of other problems, which suggest many sub-departments (dealing for example with explosives, metal production, photographic chemicals, etc.), and ultimately differentiation into separate national institutes.

*National chemical laboratory*

(iv) There must be at least one institute to deal with those smaller industries which demand a high standard of scientific efficiency. The work done in the old Kew Laboratory was excellent of its kind, and kept fairly in view the industrial factor; the testing of watches, chronometers, barometers, and thermometers must be supplemented by work on microscopes, theodolites, telescopes, and a multitude of optical instruments used in pure or applied scientific work. The Admiralty or War Office should

*National institute for the smaller industries*

know at once where to turn for a report on telescopes or telemeters, and upon the reliability of instruments made here or abroad. Nor does the above list by any means complete the round of important smaller industries where scientific control, standardizing, testing, or advice is desirable. As the scientific training of the nation, from the handworkers to the organizing leaders of each specialized industry, goes on, the need for national institutes, as centres for collecting information, for maintaining high standards of production and controlling the relations of industry to the state, will grow more and more pressing, and the differentiation of the above institutes and the foundation of new ones must be taken in hand. It will be clear that it is not possible to deal satisfactorily, from the industrial side, with such consultant bodies as we have sketched when they are merely sub-departments of a National Physical Laboratory. They must be placed in the hands of leading and independent *technical* authorities.

(v) *National Astronomical Observatory.*

(vi) *National Meteorological Office.*

(vii) *National Geographical and Geological Survey Office.*

The institutes comprised under (v), (vi), and (vii) have been for years in effective existence, but perhaps have hardly been developed on a sufficiently wide or imperial basis. The link between the central home observatories and those in the colonies and dependencies has hardly been strong enough, nor the whole chain of institutes systematized; and this is particularly the case in the meteorological service. There is

no central authority for collecting and storing the meteorological data of the empire. In some cases records are taken at scientifically important stations, but no returns are made, still less printed. Often months or years of record will be omitted. In other cases returns are made by the naval authorities, by the army medical service, by colonial botanical superintendents, etc. etc., and returns have to be sought for at the Admiralty, Netley, Kew, or vainly at the Colonial Office. Colonial data, unless printed, rarely reach this country, which from the imperial standpoint is far behind Portugal in the systematization of its meteorological service[1]. It must never be forgotten that the meteorological condition of the world at any given time is a complex unity, and the state of the atmosphere in Northern Norway is correlated with the contemporary conditions even of St Helena and the Cape. The world-wide extent of the British Empire presents opportunities in this direction which are far from utilized at the present time, and the extension and "imperialization" of all three of the institutes just referred to must be an important task for the immediate future.

*Further national institutes of science*

*Meteorological service*

Thus far we have dealt chiefly with the inorganic or physical sciences *applied* to the service of the state. In several of these sciences there have been, and undoubtedly will in future be, demands for state institutions for research in pure science. Now although the boundaries of pure and applied

*The state and pure-science institutes*

[1] Written in 1902, but not without experience!

science are in some cases ill-defined, yet we believe a working distinction can be made, especially if we remember that the first, if not, however, the whole function of a national institute is to collect data and apply existing knowledge. It is to the academic bodies that we should look for real advance in pure science, and this will become the more feasible the sooner it is recognized that it is the function of these bodies to teach by research, and that the members of their staff who merely teach and do not research are not teaching in the proper manner. Hence any cry for national laboratories for pure science must weaken the legitimate demand of the universities for effective municipal and state support for their laboratories. The university laboratories for research and post-graduate students are, and ought to be, the true national laboratories for pure science. Of course they want, especially on the biological side, wide extension and development.

Turning now to the organic side, we see at once the fundamental importance of: (viii) *National Institute for Preventive Medicine* and (ix) *National Institute for Sanitary Science*.—Here again there are innumerable questions to which municipalities, or home and colonial governments, need answers, and definite and prompt answers. It is little good, after an army has been decimated by enteric, to appoint a commission to inquire into the causes of it: advice and control on the point should have been provided before the army started. Pollution of rivers, provision of vaccine and antitoxin, the treatment of malarial districts, are not

*Medical and sanitary institutes*

topics to be left on one side until public attention forces the government to action; they and many other matters are not effectively dealt with by private corporations, individual research, or hurriedly constituted commissions; the staff of government institutes should have been steadily pegging away at them, collecting data and experimenting, so as to be ripe with information when the state demands aid, or popular interest, tardily excited, calls for expert opinion.

(x) *National Institute for Anthropology.*—With possibly more races under the British flag than under any other imperial symbol since the days of the Roman eagle, we have yet entirely failed to systematize and nationalize our study of those races. There is no national museum or institute where one may learn the cranial, anthropometric, and physical characters of the various races under our sway, still less something of their languages, folk-customs, industries, and religions. An institute carrying out a complete anthropological survey of the empire is as necessary from the imperial standpoint as those dealing with the geographical or geological surveys. The Americans have recognized this, and their anthropological reports and museums under state supervision will soon be a model for such work everywhere.

*National institute for anthropology*

(xi) *National Institute for Botany.*—The importance of this has been long recognized, and Kew with its associated botanical gardens in the colonies and dependencies forms a great organization which justifies further support and wider extension. A special

department, or even a separate institute, ought to be devoted to agricultural economy, while a further institute or sub-department must be devoted to forestry. The re-foresting of large tracts in Great Britain —for example, miles and miles of grouse moor, where, as in the Schwarzwald, the deer and capercailzie might still serve to train the sight of those who can walk as well as stand—is a matter of growing importance; while the economic usage, not "use-up-age," of colonial and African forests is a matter which demands trained intelligence and wise control. As Professor F. O. Oliver has suggested, the outdoor life involved in planting, tending, felling great national forests—and, we may add, the training in sight and scouting involved in game preservation—would be excellent work for army-reserve men. The foresters would be a great body of fit men who could, like the coastguard, be at once drawn upon in time of need, without upsetting great national industries or important systems of transit. The organization of a forest service, which should ultimately be imperial rather than local, would provide excellent material for the experts of a Forestry Institute; while at the present rate of consumption the exhaustion of existing supplies will render even pine forests self-supporting by the middle of the century.

*National institute for botany*

(xii) *National Biological Institutes.*—Here again great differentiation and much extension are requisite. If we preserve, as seems fitting, the principle that the national institutes are in the first place for applied

*National biological institutes*

science, and that the state directly undertakes pure scientific work only when it cannot do it indirectly through support to academic laboratories, then we may perhaps see some light through a rather complex situation. We need first an *Institute for Marine and Riverine Fisheries*, solely devoted to the study of these matters from the industrial standpoint. The existing marine biological laboratories have principally, although not entirely, opened opportunities for research in pure science, and they are likely to become still more closely associated with one or other academic body or group of universities. The Institute for Fisheries should be the head-centre of the government fishery inspectors, the store for statistics of home and deep-sea fisheries, and the place for the experimental development of all industries relating to fish,—catching, curing, and transit,—as well as for the control of these industries. Such investigations only hamper the development of pure science, which requires marine laboratories for its own purposes. Turning to land fauna, we need in the first place a *National Zoological Institute*, which would, like the Geological and Anthropological Surveys, report on living forms within the limits of the empire, with special reference to the preservation and spread of such as are of industrial importance or agricultural fitness for special climates or tasks. This institute should be in close touch with government studs, and with the custodians of zoological reservations in the colonies and dependencies. The Royal studs should be developed into national studs, where secular ex-

*National zoological institute*

periments might be carried on with horses and cattle, and interchanges made with the like studs in the outlying parts of the empire,—in the same manner as interchanges are now carried on between Kew and its allied botanical gardens. Such an institute should be able to report at once on the best type of animals for a given district or climate, and on the fodder and animal or insect foes there to be met with. Here again we are behind the Americans, who are already starting "state farms" for the experimental investigation of the laws of heredity and their application to animals used in agricultural industries. Naturally a special study of the smaller wild animals, birds, and insects, from the standpoint of their importance to husbandman, fruit-grower, and farmer, would be undertaken as a special department of the Zoological Institute. It would be the consultative faculty of the Board of Agriculture, and of many county councils in rural districts. This institute should deal with close seasons, game laws, wild-bird protection, and insect destruction on a firm scientific basis, and seek the transfer and acclimatization of new and useful species of both wild and domestic animals.

*The biological farm*

Corresponding to such an institute, with its associated group of national breeding establishments and zoological reserves, we must hope in the near future to see the establishment, in the interests of pure science, of one if not more fully-equipped *Biological Farms*. The Biological Farm or Garden has a perfectly definite scientific mission alongside the Biological Laboratory. There is a great range of problems bearing on

the evolution of living forms, their variation by natural selection, their laws of inheritance, the origin of species, and the differentiation of local races, which can be solved only by experiment on "populations," carried on under nearly natural conditions, or on a large scale, from generation to generation. Such statistical and secular experiments cannot be satisfactorily undertaken in existing biological laboratories: they need a considerable range and variety of land, water, wood, and open field, free from intrusion and under the management of skilled keepers; there must be sheds for the breeding of, at any rate, the smaller mammals, houses for insects and birds, and ample space of all kinds for all sorts of extensive experiments on heredity and variation. There must be, in addition, workrooms, microscope rooms, dissecting laboratories, and instrument departments for the use of measurers, computers, and researchers. Such a biological farm could in the present state of affairs do epoch-making work within the space of a very few years. There are all-important questions in variation and heredity which cannot be settled by individual experiment, owing to the labour, the time, and the freedom from bias required. There must be trained servants—keepers or gardeners—to tend, in the absence of the directing researchers; there must be facility for inspection at any time, so that there can be no question of how characteristics are measured, or of personal equation in the interpretation of results. It ought to be perfectly possible in a few years to determine, to the satisfaction of all parties concerned, the limits of truth in the laws propounded by Galton,

or Mendel, or any other; and only by such unbiassed experiments, not by controversial publications, can the actual facts be reached. It is admitted on all sides that we stand here, in the matter of variation and heredity, on the eve of wide-reaching discoveries, and only an institute such as we have here sketched can really conduct the extensive and secular experiments which are needed for truly authoritative answers.

*National importance of the laws of heredity, etc.*

Such answers, when found, will not only be of vast importance to pure science, but of wide practical usefulness in stock-rearing, horticulture, and agriculture. Nor is their value limited to the lower forms of life. The crowning study of man is man; the highest science is that which deals with human races, and sees the causes which lead to their progression and relative dominance. This science, applied to national life, is statecraft,—the art of seeing what makes for national health and for national fitness. Every nation, however, is an agglomeration of classes and castes, of the mentally and physically healthy, and of the mentally and physically unsound. Man, if the highest of living forms, is still one of them; and it is easy to test whether the general laws of heredity and relative fertility proved for the lower forms hold, with or without modification, for him. Problems as to the reproductive dominance of the better stocks, as to effective national fertility, as to progressive physical and mental development in man, will be vital problems for the statesmen of the near future; their solution is closely bound up with a knowledge of the laws of heredity, fertility, and varia-

tion in other living forms, which only such an institute as we have just described can effectively study.

With the Biological Farm we must conclude our too brief account of some of the institutes which are essentially necessary for increasing and circulating the knowledge which is the life-blood of the modern state.

## IV

## RECORDS OF SCIENTIFIC DISCOVERY

Passing for a moment to the conditions under which newly discovered knowledge is published, we find, both from the national and international standpoints, considerable confusion and overlapping of functions. Placing on one side book publication,—in which form, perhaps, less and less original work sees the light,—we have two chief methods of issue, the scientific journal and the proceedings or transactions of learned societies. The national work done by both journal and society is often deserving of far greater recognition than it receives; in many cases the publication funds depend solely on the range of either subscribers or members, and editors and councils are occasionally compelled to keep up their numbers by the issue of memoirs which do not reach the high-water mark of scientific research. Permanent endowment of journals and societies is a more or less urgent need, and we could wish that the millionaire with patriotic instinct would occasionally realize that to set one scientific society or journal firmly on its legs

*Methods of publication*

may do more real good than the establishment of an additional free library. The further endowment of University Presses with trust funds for the publication of non-paying scientific and scholarly works is also a form of public benefaction which should be heartily commended. The reputation of a great university, the width of knowledge at the service of its press committee, may in some respects afford better security for the publication of first-class work than can be provided even by a strong editorial committee in a specialized branch of science.

*Need for specialization in scientific journals*

If we demand for scientific journals and societies permanent endowment, we must also demand from them increased specialization, and in many cases a higher standard of publication. At present memoirs of a given class may appear in perhaps a dozen different journals or proceedings. We may hope in the future that national journals may assume a more international character, and then specialization would become more and more feasible[1]. Such specialization is needful, not only for the efficiency of editorial committees, and for the facility of reference, but would ultimately extend circulation.

[1] There are, for example, perhaps a dozen journals of mathematical research, of which at least five or six are of the first class. But nearly each one covers the enormous range of pure and applied mathematics, and a mathematical paper may have to be hunted for not only in these, but in twice as many more proceedings or transactions. Both pure and applied sides require to-day in publication (as in teaching) wide-reaching differentiation, and a specialization of mathematical journals on international lines would be a great gain.

A specialist will take in one or two journals devoted to his own branch of science, but he cannot afford a round of publications which partially and intermittently touch his special field. He trusts to the library rather than to the study shelves, and thus the total number of subscribers to scientific literature is permanently reduced.

The progressive specialization and differentiation of learned societies are of course familiar to every student of the formal history of science, and it becomes a grave question how long national academies and royal societies can maintain their old lines of publication or constitution. Under the present arrangement the most highly specialized and, perhaps, the best work does not reach these societies at all; and the leading specialists may be far more interested in the work and executive of special societies or journals for astronomy, biology, or geology, than in those of the academy or society which is supposed to be the representative of national science. It weakens the reputation of the leading society to publish special memoirs distinctly inferior to those issued by a specialized society or journal[1]; it is undesirable, on the other hand, that the leading society should skim the cream of special journals and transactions, if indeed it lie in its power to do so. The coordination of learned societies and the organization to a common end of their publications is a matter of

[1] The mixed character of the papers communicated, even at a single sitting, to a national academy or society makes a really valuable discussion, such as may well arise in a specialized society, rarely possible.

some difficulty, but of a pressing character. It may be doubted whether a central society, discussing and publishing communications bearing on almost every field of knowledge, is fitted to survive in the highly specialized science of the future. Rather such a central society needs differentiation into astronomical, mathematical, physical, biological, geological, physiological, and other sections, each of which is now more or less effectively provided for by one or more special societies. In our own case we might render the whole work of science much more effective if the publications of these societies—proceedings and transactions—were rendered uniform in format, and the first stage to publication[1] by the Royal Society, or to its membership, were through these specialized or co-ordinated societies. In this way a much higher standard of publication and of membership might be reached, especially if the executive of the central society were a body fully representative of the executives of the co-ordinated societies. Thus the Royal Society's *Transactions* and *Proceedings*, off-printed from the sectional publications, would embody the best and most representative scientific work of the nation; this selection, embracing most of originality and progress in the year's scientific work, would be offered as an incentive in style and matter to individual workers, and as a

*Co-ordination of existing learned societies*

[1] It would be needful to maintain a general publication, co-ordinate with those of the specialized societies, for work in new fields—often the most important type of work—not yet recognized as a part of any differentiated section.

résumé of the best in national work for international criticism and exchange. Whatever direction reform of the Royal Society and co-ordination of existing scientific bodies may take, it is hardly possible that by the middle of this century the Royal Society can remain with its present *olla podrida* in publication and membership, and yet maintain its reputation or influence.

## V

## STATE RECOGNITION OF SCIENCE

We have already referred to a more or less fundamental distinction that exists between the two types of scientific workers,—those who adopt science and research as a profession, and those who are impelled to investigate by an uncontrollable curiosity, to which in our higher flights we are tempted to give grandiloquent names. As in other callings, so in science the bulk of men, from forces of external circumstance and of internal character, must belong to the first class, and the usual incentives of endowment and state recognition are needful as spurs. The state of the future, the welfare of which will so largely depend on science, must provide such rewards of this kind as seem necessary. In this respect the institution of a particular grade, say that of State Science Counsel, with a patent like that of the existing King's Counsel, might serve to mark the field in which distinction had been gained, and so by differentiating the reward differentiate scientists as a class from provincial mayors and successful traders or financiers. The

*State science counsel*

whole body of State Science Counsellors might form the State Science Council. This would consist of the directors of the national institutes, of the most distinguished pure science professors in the universities, of the leading teachers in the principal technical and government schools, and of any other persons of great scientific achievement. It would form the chief scientific consultant body to which government or any public authorities could appeal in cases of difficulty. Out of the members of such a council, investigating and advising commissions might be nominated by ministers of state. It would probably be undesirable to summon such a Science Council as a whole, or give it officers or corporate existence. Many of its members at any given time might be beyond active scientific work, but, as in the case of other state councils, selected members only might be summoned for special committees and special types of work. It would provide a body from which men far better able to advise the state could be drawn, than the council of any existing society. For it would involve specialists in all branches of pure and applied science, having the instruments of research at their disposal, and would be essentially practical and national in its character. But in the selection of the right type of man to aid the state in a particular function, we come back to the point from which we started—to a knowledge wholly different from scientific knowledge. Science in the end, if it is to be of the highest national service, must be subject to a different type of knowledge—to that experience of men, that power

*Science and statecraft*

of selecting the fit man for the fitting task, which is summed up in statecraft. We need men in every department of state who have insight into character, who can judge the man who is capable of achieving, without having studied his creative work or knowing the "ropes" of his special science. Herein the position of science in both Germany and France is better than in Great Britain, for there is a closer association of the scientific and governing castes; we do not want an increase in the number of parliamentary scientists, for in deserting science they have not become statesmen. It is a matter where closer personal knowledge and a more intimate contact of men of diverse pursuits have to be brought about. Such considerations lead us again to the training of statesmen; it seems far easier to develop the scientific knowledge of a nation than to increase its store of statecraft. Educate intelligently the craftsmen who form the basis of social life and the bulk of the electorate; then, perhaps, the politician who appeals to them will need to reach a higher standard; he, in his turn, will demand graver qualities and more weighty capacity in his leaders than at present: power of organization, insight into character, true executive ability, will weigh more than ready repartee, mere force in verbal criticism, or the other special aptitudes developed by a parliamentary training. But it is a long way up from nature-study in the village schools, and the heuristic method in craft-schools, to this; it may sound paradoxical to some, and a counsel of perfection to many. Yet the nation, from the bottom to the top, has yet to learn that

trained intelligence in all functions is the factor which makes for victory in the modern international struggle. It may be a lesson taught by the wisdom of statesmen, or bitterly by the stress of defeat and famine. We have by one or other process to learn the national importance of science: to realize that science in the broadest sense, as educator and discoverer, is the mainspring of modern national life; that the future is to the scientifically trained nation which reproduces itself, maintains its health, develops its institutions, controls its production, organizes its distribution, extends its territory, governs its subject races, and prepares its offensive and defensive services with scientific foresight and insight—

> In the reproof of chance
> Lies the true proof of men—

and, we may add, the true proof of nations.

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